# THE RELATIONSHIPS BETWEEN WATER MASSES AND EUPHAUSIIDS IN THE GULF OF CALIFORNIA AND THE EASTERN TROPICAL PACIFIC

by

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United States
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# THESIS

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ABSTRACT

The object of this investigation was to determine the relationships between the euphausiid populations and the surface and subsurface water masses in the Gulf of California and the Eastern Tropical Pacific. The data was collected during two three month cruises of the R/V TE VEGA. Aspects of the horizontal and vertical distributions of both the euphausiids and the water masses are presented. Euphausiid distributions found by another investigator are presented for comparison. The study was based on 120 trawls which fished for a period of one hour each with an opening and closing Tucker midwater trawl. Thirteen different species of euphausiids were caught. The data suggests that there is no direct relationship between the distribution of euphausiids and the distribution of water masses in the limited area considered. New extensions of the horizontal and vertical ranges of several species of Pacific euphausiids are included.

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# I. INTRODUCTION

The object of this investigation was to determine if there were any relationships between the euphausiid populations and the water masses, both surface and subsurface, in the Gulf of California and the Eastern Tropical Pacific and, if so, what they were. Aspects of the horizontal and vertical distributions of both the euphausiids and the water masses encountered are presented.

The euphausiids are almost purely planktonic, and are largely oceanic (Banner, 1949). With only four exceptions, they live above a depth of 1500 meters (Brinton, 1962). The euphausiids, among other organisms, are suspected to be important in the scattering of sound in the deep scattering layers (Boden, 1950; Moore, 1950; Dunlap, 1968). They are considered second in importance only to the copepods as basic animal food in the sea and often exceed the copepods in mass and numbers (Boden et al, 1955). In fact, euphausiids (or perhaps pteropods) are probably the most abundant creatures on earth (Ricketts and Calvin, 1968). These would seem to be sufficient reasons for the intense systematic study of euphausiids.

Euphausiids feed largely on phytoplankton and in turn are eaten by fish and the whalebone whales (Banner, 1949). At a time when human beings go hungry in many parts of the world these vast populations go unharvested by man. The Russians (Ricketts and Calvin, 1968) and the Japanese

(Boden *et al*, 1955) have taken steps to harvest this untapped source of food.

Extensive previous studies have been made on euphausiid distributions by Brinton (1962, 1967) and the results presented here will be compared with his.

The Eastern Tropical Pacific has been defined as the region lying between the Tropic of Cancer and the Tropic of Capricorn and eastward of 130°W to the continents of North and South America (Wooster and Cromwell, 1958). For the purposes of this investigation this definition will be altered in order to fit the area from which the data was collected. For this paper "Eastern Tropical Pacific" will mean that region southward of 30°N, northward of 10°S, and eastward of 115°W to the coast.

The data on euphausiid distribution comes from examination of 120 samples collected by LT. Calvin Dunlap, USN, during cruises 16 and 17 of the R/V TE VEGA. Cruise 16 was mainly in the Gulf of California and extended from September 22 to November 14, 1967. Cruise 17 was in the Eastern Tropical Pacific and was from January 3 to February 15, 1968. Figures 1 and 2 show the horizontal positions of all trawls and Figures 3 and 4 show vertical positons.

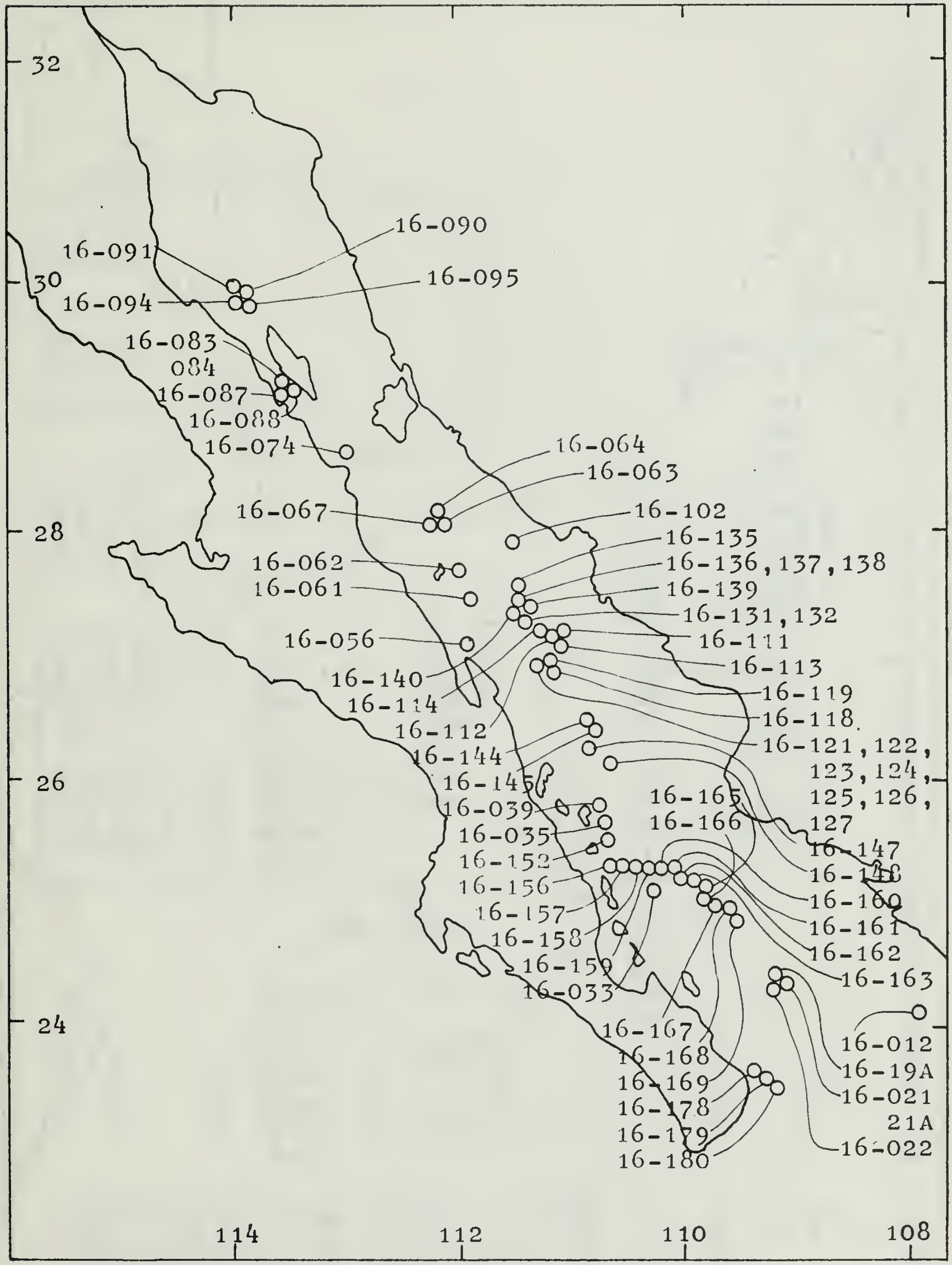



Figure 1. Horizontal Distribution of Trawls in the Gulf of California

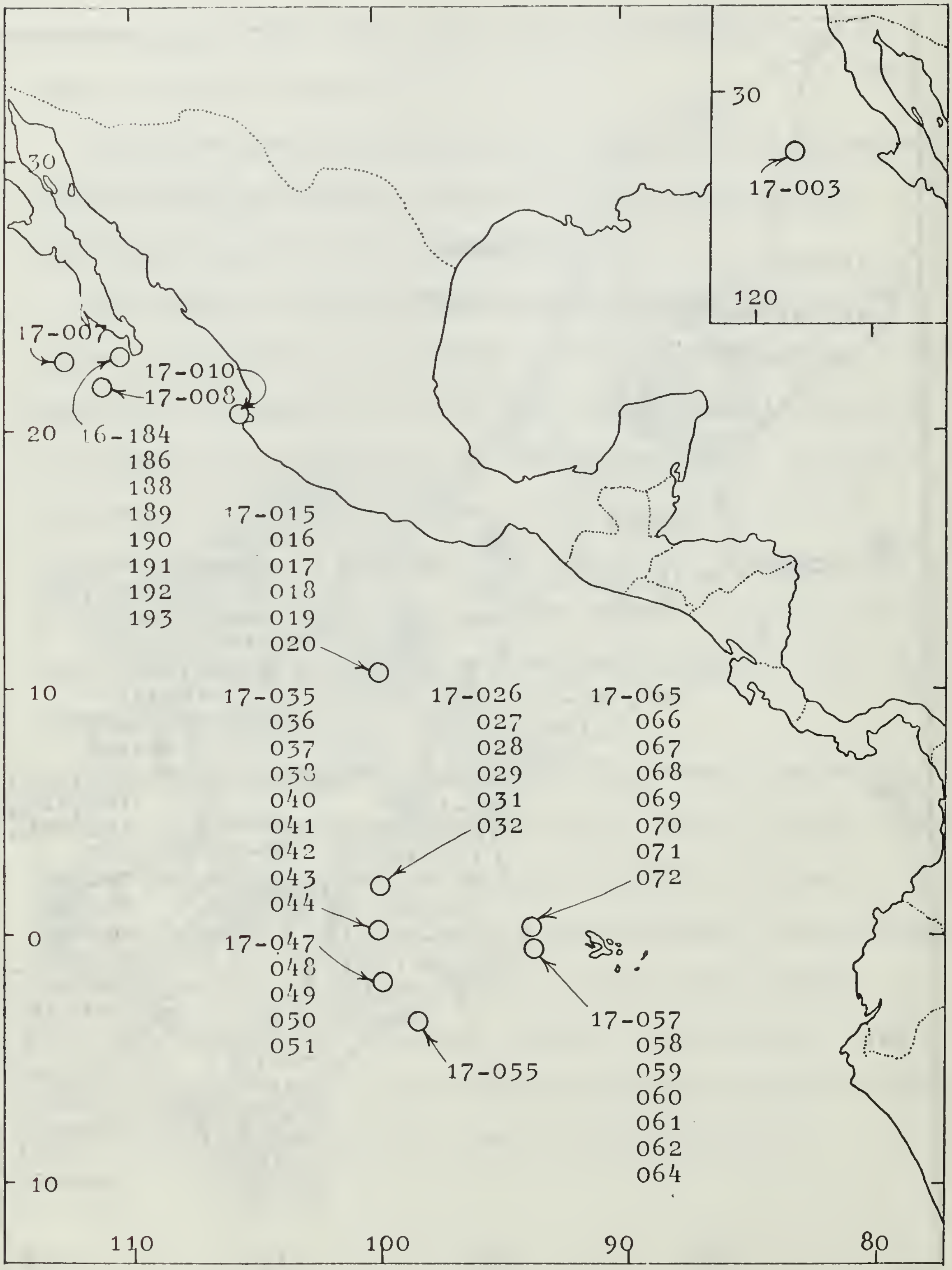



Figure 2. Horizontal Distribution of Trawls in the Eastern Tropical Pacific

| DEPTH (m) | DAY | | | NIGHT | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| 0- | 16-012 | 16-140 | | 16-021 | 16-022 | 16-061 | 16-083 | 16-113 | |
| 50 | 16-094 | | | 16-21A | 16-056 | 16-067 | 16-102 | 16-127 | |
| 50- | 16-124 | 16-169 | | 16-033 | 16-084 | 16-095 | 16-119 | 16-131 | 16-139 |
| 100 | 16-138 | | | 16-039 | 16-090 | 16-114 | 16-126 | 16-132 | |
| 100- | 16-063 | | | 16-156 | | | | | |
| 150 | 16-163 | | | | | | | | |
| 150- | 16-074 | 16-137 | | 16-148 | | | | | |
| 200 | 16-121 | | | | | | | | |
| 200- | 16-19A | 16-122 | | 16-091 | 16-178 | | | | |
| 250 | 16-087 | | | 16-152 | | | | | |
| 250- | 16-161 | | | 16-118 | | | | | |
| 300 | | | | 16-125 | | | | | |
| 300- | 16-062 | 16-136 | | 16-157 | | | | | |
| 350 | 16-135 | | | 16-166 | | | | | |
| 350- | 16-035 | 16-111 | 16-160 | | NO DATA | | | | |
| 400 | 16-064 | 16-145 | 16-162 | | | | | | |
| 400- | | NO DATA | | | NO DATA | | | | |
| 450 | | | | | | | | | |
| 450- | 16-088 | | | 16-165 | | | | | |
| 500 | | | | 16-180 | | | | | |
| 500- | 16-144 | | | 16-158 | | | | | |
| 550 | | | | | | | | | |
| 550- | 16-123 | | | | NO DATA | | | | |
| 600 | | | | | | | | | |
| | OTHERS | 850-900 | 16-112 | 600-650 | 16-179 | | | | |
| | | | | 1000-1050 | 16-167 | 16-168 | | | |
| | | | | 1450-1500 | 16-147 | | | | |
| | | | | 2250-2280 | 16-159 | | | | |

Figure 3. Diurnal Vertical Distribution of Trawls in the Gulf of California

| DEPTH (m) | DAY | | | NIGHT | | |
|---|---|---|---|---|---|---|
| 0- | | NO DATA | | 17-003 | 17-026 | 16-190 |
| 50 | | | | 17-020 | 17-028 | |
| 50- | 17-016 | | | 17-044 | 16-188 | |
| 100 | | | | 17-051 | | |
| 100- | 17-050 | | | 17-019 | | |
| 150 | | | | 17-068 | | |
| 150- | 17-058 | 17-061 | | 17-035 | | |
| 200 | 17-060 | | | 17-062 | | |
| 200- | 17-010 | 17-040 | 16-191 | 17-037 | | |
| 250 | 17-015 | 17-041 | | | | |
| 250- | 17-008 | 16-193 | | 17-007 | | |
| 300 | 17-070 | | | | | |
| 300- | 17-047 | 17-066 | 17-072 | 17-067 | | |
| 350 | 17-048 | 17-069 | | | | |
| 350- | 17-032 | 17-043 | 16-184 | 17-038 | | |
| 400 | 17-042 | 17-057 | | | | |
| 400- | 17-017 | | | | NO DATA | |
| 450 | 17-071 | | | | | |
| 450- | 17-049 | | | | NO DATA | |
| 500 | | | | | | |
| 500- | 17-059 | | | 17-027 | | |
| 550 | | | | | | |
| 550- | 17-018 | | | 17-036 | | |
| 600 | | | | | | |
| | OTHERS | 1000-1050 | 17-031 | 650-700 | 16-186 | |
| | | | 16-192 | 750-800 | 16-189 | |
| | | 2000-2050 | 17-065 | 1000-1050 | 17-029 | 17-064 |
| | | | | UNKNOWN DEPTH 17-055 | | |

Figure 4. Diurnal Vertical Distribution of Trawls in the Eastern Tropical Pacific

## II. MATERIALS AND METHODS

To collect the samples a modified Tucker net (Tucker, 1951) with a special opening and closing device constructed by the Naval Undersea Research and Development Center (Davies and Barham, 1969) was used (see Fig. 5). The net had one-quarter inch mesh at the cod end. One hundred twenty trawls were made.

This study was based on a subsample composed of one-third of the catch which is deposited at the Naval Post-graduate School. The other subsamples are deposited at the Hopkins Marine Station and the Marine Station of Puerto Penasco, Mexico. Eighteen samples contained no euphausiids. One hundred two samples contained from one to 5000 euphausiids each. About 90 of the samples containing less than 1000 specimens were examined in full. The euphausiids were first separated from the other organisms, then each individual euphausiid was examined and identified. The remainder of the samples were considered too large (estimated to be more than 1000 specimens) for individual examination. These samples were thoroughly mixed and a subsample of about 200 to 300 representative specimens were removed in a random manner. These were then examined and identified. The count was then multiplied by an appropriate factor to give an estimate of how many of each species was present in the entire sample. The remaining part of the sample was examined to assure that no other species were present. This

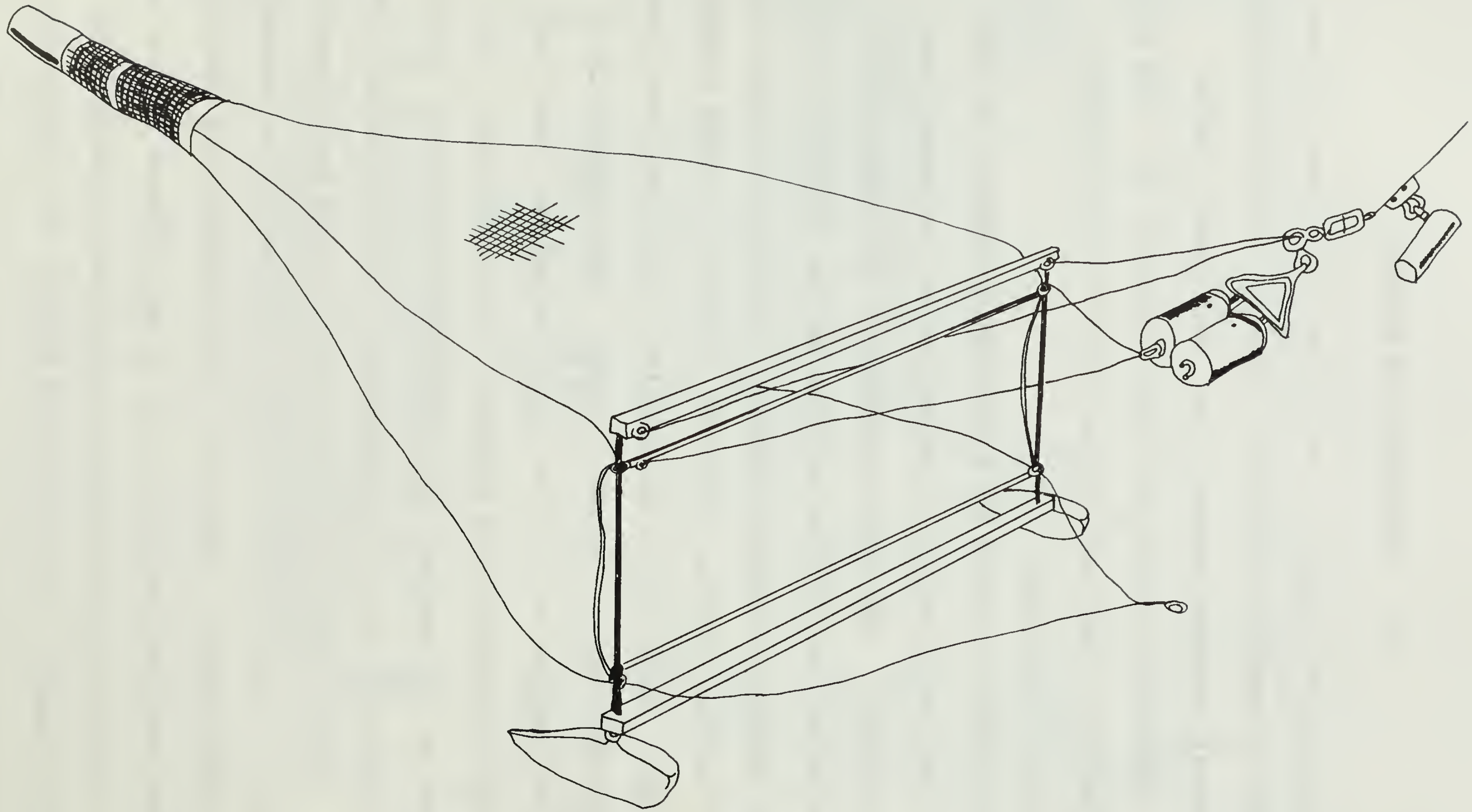


Figure 5. Modified Tucker Trawl used for Sampling. (After Robison, unpublished Te Vega Cruise 16 manuscript)

procedure (which took six months) accounted for a total of 42,994 euphausiids of 13 different species.

In the horizontal and vertical distributons that follow, the term "dominant" means that that species was the most numerous species in a sample, "subdominant" means it was the second most numerous species, and "present" means the species was present in the sample but was not dominant or subdominant. In a few of the samples there were the same number of specimens of two or more species. In this case each was listed as dominant or subdominant. On the maps that follow, each trawl (or in some cases several trawls) is represented by a circle. The circles are marked as follows for each species:

● = dominant

⊕ = subdominant

⦶ = present

○ = absent

Where trawls are so close together that there must be more than one trawl represented by a circle on the maps, the plot is made for the highest category that occurs for any trawl represented by that circle. For example, if a species is dominant in one trawl but only present in another and both are represented by a single circle, that circle would be completely shaded. This procedure was used because of the lack of knowledge of the amount of water filtered by each trawl since attempts to measure net flows were unsuccessful. The usual procedure of plotting the individuals per unit volume filtered was therefore impossible. This procedure resulted in a "relative abundance" instead of an "absolute abundance" plot. None the less, this method was considered to provide information on the abundance of the different species in the various locations. A similar method based on percentages of the total catch has been used before by Moore (1952).

A continuous depth-time recorder attached to the trawl was used to determine trawl depth. Each trawl was opened for one hour at a selected depth. The net was towed at two knots, resulting in a two nautical mile tow. Trawl times were scheduled so as to avoid the diurnal migration periods in the early morning and late afternoon. On cruise 17, trawl data was corrected to a standard two nautical mile tow when ship speed varied from two knots. This assured that all trawls sampled as near the same volume of water as possible (neglecting currents).

Hydrographic data was collected from 40 standard hydrocasts to at least 1000 meters.

## III. OBSERVATIONS AND RESULTS

### A. WATER MASSES

#### 1. General

Water masses can be classified on the basis of their temperature-salinity characteristics (Sverdrup et al, 1942) following the procedures of Helland-Hansen (1916). This method will be used here. The surface water masses of the Gulf of California will also be defined by phytoplankton content as given by Round (1967). This is reasonable since the water has common characteristics and is present in a definite area. The surface water masses of the Eastern Tropical Pacific will be described first, followed by the subsurface water masses of the same area, the surface water masses of the Gulf of California, and finally the subsurface water masses of the Gulf of California. Following this verbal description are a number of figures that depict the T-S relationships of the water masses and the boundaries of the surface and subsurface masses. The surface water mass boundaries are subject to seasonal fluctuations and are zones rather than lines (Wyrtki, 1967). These surface water masses are characterized by the different climatic conditions in the region of occurrence. Transition areas have been indicated in figures by crosshatching. The descriptions of the water masses are compiled from both the hydrocast data and the work of Wyrtki (1967), Roden and Groves (1959), Round (1967), and Roden (1958).

2. Eastern Tropical Pacific

a. Surface Water Masses

(1) California Current Water. The surface water of the Northern portion of the Eastern Tropical Pacific is California Current Water which has characteristics of moderate temperature and low salinity (Wyrtki, 1967). Near the tip of Baja California this water meets water from the Gulf of California and Tropical Surface Water. Figure 6 gives the T-S relationships of this and all other water masses. Figures 7 and 8 show the limits of this and the other surface water masses.

(2) Tropical Surface Water. South of the California Current Water is a region where precipitation exceeds evaporation and sea surface temperatures are high. The water in this area is called Tropical Surface Water by Wyrtki (1967). Here the surface temperature is always greater than 25°C and the salinity between 33 and 34°/oo. The northern boundary is near 15°N ± 5°, depending on the time of year. The southern boundary extends from Ecuador to north of the Galapagos Islands and thence west along about 4°N (Wyrtki, 1967). Data from TE VEGA cruise 17 agrees with this northern boundary and indicates the southern boundary to be about 2°N. This layer is only 20 to 50 meters thick, except along the southern boundary where it can be as much as 100 meters thick.

(3) Equatorial Surface Water. South of the Tropical Surface Water is a water mass intermediate in

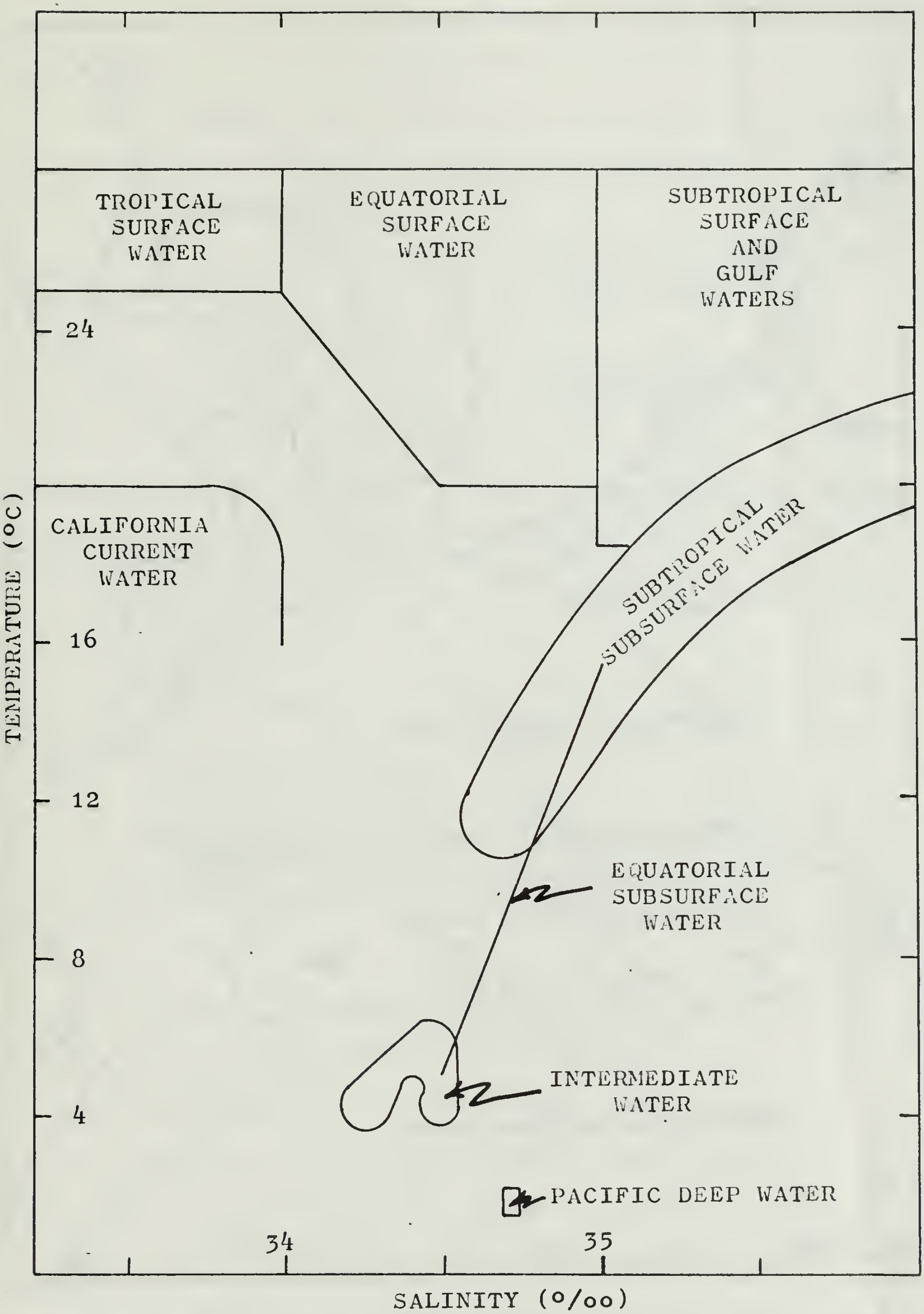



Figure 6. Temperature-salinity diagram. (After Wyrtki, (1967), Roden and Groves, (1959), and Von Arx, (1962))

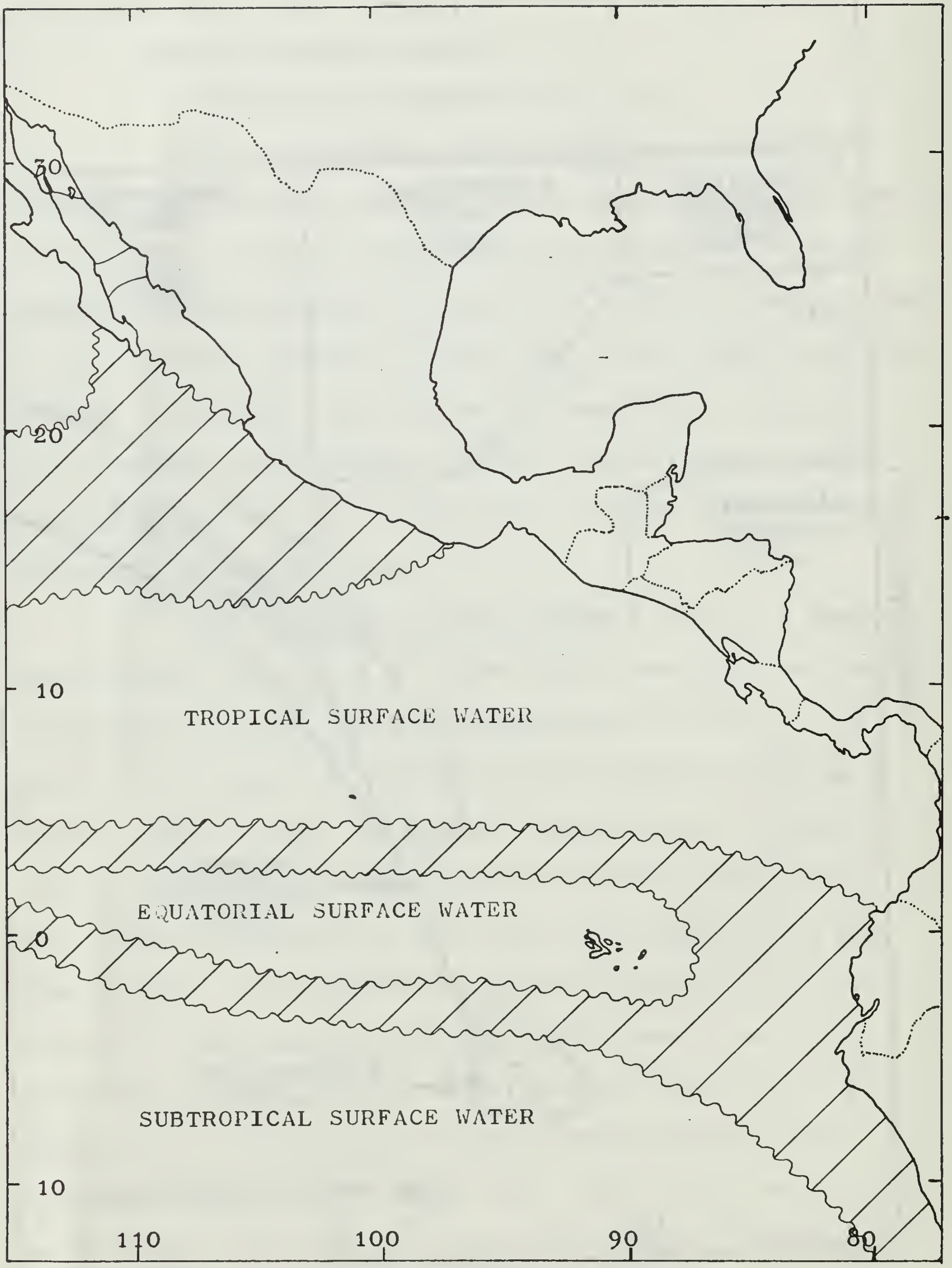



Figure 7. Geographical locations of surface water masses and transition zones (hatched). (After Wyrtki, (1967), Roden and Groves, (1959), and Round, (1967))

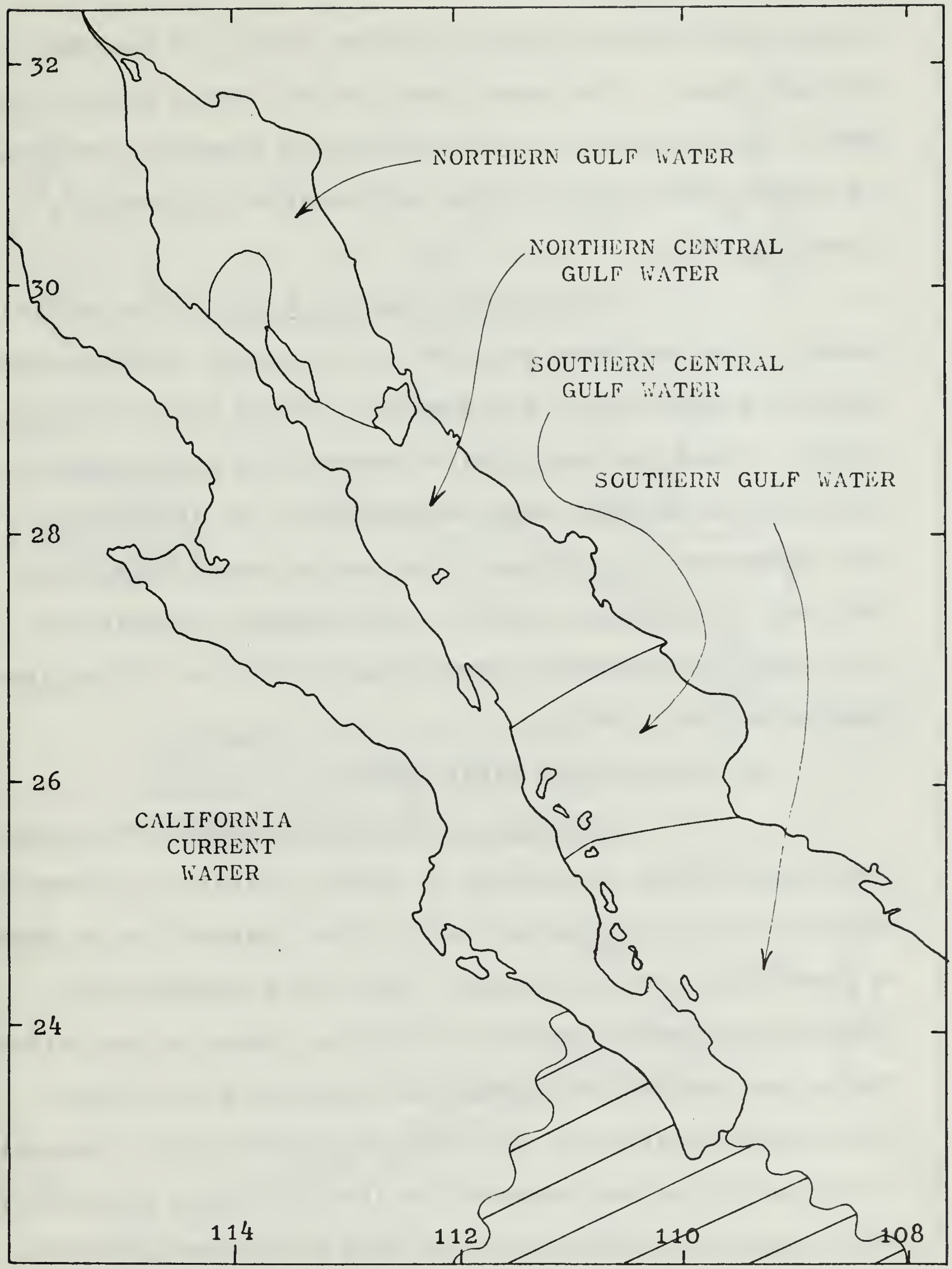



Figure 8. Geographical locations of surface water masses and transition zones (hatched). (After Wyrtki, (1967), Roden and Groves, (1959), and Round (1967))

properties between Tropical Surface Water and Subtropical Surface Water. This water mass is not just a mixture of the two. Its properties are determined by seasonal advection of cooler Peru Current Water and equatorial upwelling (Wyrtki, 1967).

(4) Subtropical Surface Water. The surface water of the southern portion of the region under consideration has been called Subtropical Surface Water by Wyrtki (1967). Here the evaporation exceeds the precipitation, resulting in a water mass characterized by high salinity, but temperature variations over a wide range from about 28°C to 15°C (Wyrtki, 1967). The northern boundary of this water corresponds approximately with the 35°/oo isohaline (Wyrtki, 1967).

b. Subsurface Water Masses

(1) Subtropical Subsurface Water. Subtropical Subsurface Water as defined by Wyrtki (1967) is characterized by a salinity maximum within the thermocline at about a depth of 50 to 150 meters. Above this maximum the salinity decreases rapidly to the low value at the surface. Below the maximum the salinities decrease more slowly. The characteristics of the salinity maximum are a salinity of about 35°/oo and temperature 16-17°C. This water mass is found almost throughout the area under consideration. See Figure 9 for boundary limits. This salinity maximum layer separates the surface waters from the deeper waters.

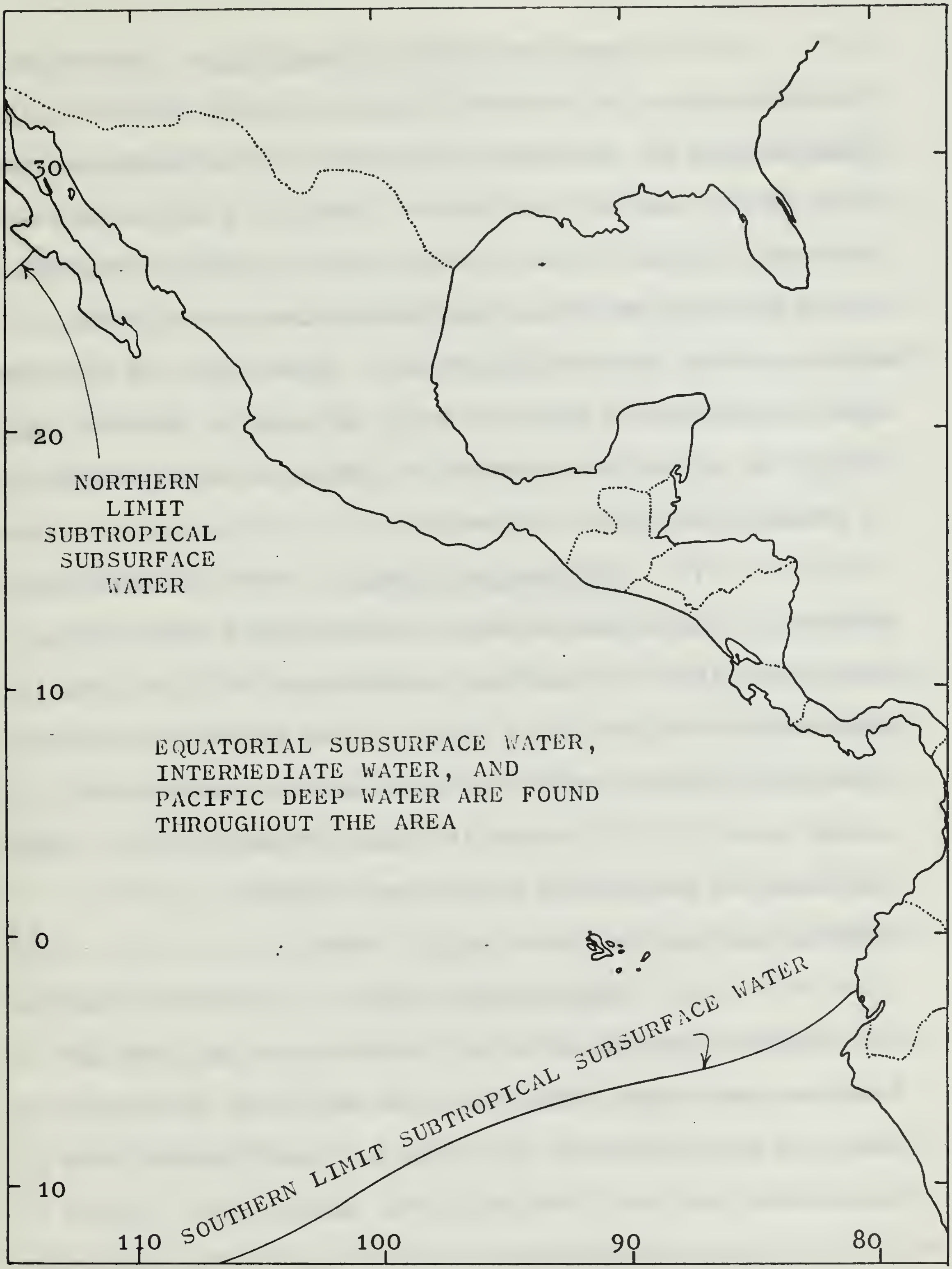



Figure 9. Geographical locations of subsurface water masses. (After Wyrtki, (1967), and Roden and Groves, (1959))

(2) Equatorial Subsurface Water. Equatorial Subsurface Water as defined by Wyrtki (1963, 1967) is characterized by an almost linear T-S relationship between 15°C, 35°/oo and 5°C, 34.55°/oo. It is a mixture of all the water between the core layer of the salinity maximum of the Subtropical Subsurface Water and the salinity minimum of the Intermediate Water. This water is identical with the Equatorial Pacific Water defined by Sverdrup et al, (1942). It contains an extensive oxygen minimum layer and is present throughout the area.

(3) Intermediate Water. The water below the Equatorial Subsurface Water is Intermediate Water with characteristics of a salinity minimum of 34.5°/oo and temperatures in the range 4-8°C. This minimum occurs at about 800 ± 100 meters in the area under consideration except north of 15°N where it rises (Wyrtki, 1967). Off the coast of California salinities decrease steadily towards the surface (Reid et al, 1958).

(4) Pacific Deep Water. In the portions of the Pacific Ocean below about 2000 meters is found the Pacific Deep Water. The characteristics of this water mass are salinities of 34.66°/oo to 34.69°/oo and temperatures of 1.5 to 2.0°C (Von Arx, 1962).

3. Gulf of California

a. Surface Water Masses

(1) Temperature-Salinity Relationships. Water of high salinity is formed in the Gulf due to an excess of

evaporation over rainfall (Roden and Groves, 1959). This water has the same characteristics as the Subtropical Surface Water of the Southern hemisphere and Wyrtki (1967) has classified it as such. Roden and Groves (1959) call it Gulf Water. The salinity of this water varies from about 35°/oo to 36°/oo and the temperature from about 15 to 30°C. The surface salinities taken during TE VEGA cruise 16 ranged from 35.1°/oo at the mouth of the Gulf to 35.6°/oo in the Delfin Basin at the extreme northern end of the Gulf. The surface temperatures varied from 23°C to 29°C (Malone, unpublished TE VEGA cruise 16 manuscript). The salinity distribution in the surface layer is very complicated and dependent upon season (Roden and Groves, 1959). The surface waters in the southern portion of the Gulf are complicated due to the meeting there of Gulf Water, California Current Water, and Tropical Surface Water.

Roden and Groves (1959) have divided the Gulf into three sections on the basis of horizontal distribution of salinity. These sectons are (1) the area north of the Ballenas Sill (about 29°30'N), (2) Ballenas Sill to 26°N, and (3) south of 26°N. The northern zone was found to be characterized by salinities above 35.4°/oo, a result of excess evaporation. The southern zone was found to be characterized by salinities below 35.2°/oo and reflects the influence of Tropical Surface Water. The central zone represents a transition area between the other two zones.

(2) Phytoplankton Relationships. Round (1967) has analyzed the diatoms, dinoflagellates, silicoflagellates, and tintinnids in phytoplankton samples collected by three cruises to the Gulf of California. Based on these data Round has suggested that four distinct surface water masses exist in the Gulf, each with its characteristic phytoplankton. In addition Round suggests that this is a relatively stable feature of the region. Since phytoplankton content in the Gulf at the time the samples utilized in this study were collected is not known, verification of Round's results is not possible. It will be assumed that Round's same zones were present when the samples were collected. These four water masses could be called Northern Gulf Water, Northern Central Gulf Water, Southern Central Gulf Water, and Southern Gulf Water, the boundaries of which are depicted in Figure 8. The Southern Central Gulf Water was considered by Round to be a transitional region between the Southern Gulf Water and the Northern Central Gulf Water.

These phytoplankton defined zonal boundaries are similar to those of Roden and Groves (1959) as given above, with Northern Central and Southern Central approximately equivalent to Roden and Groves central zone. Keeping this in mind, Round's zones and the names given them here will be used hereafter.

b. Subsurface Water Masses

(1) Subtropical Subsurface Water. The salinity maximum that characterizes Subtropical Subsurface Water within the thermocline was clearly noted in the data from the southern portion of the Gulf, but, due to the high surface salinity north of this area, the salinity maximum does not appear. However, the waters within the thermocline do exhibit the characteristic salinities and temperatures and can be called Subtropical Subsurface Water. This water extends as far north as the Ballenas Sill and separates the surface layer from the deeper layers.

(2) Equatorial Subsurface Water. Equatorial Subsurface Water is present in the Gulf below the Subtropical Subsurface Water in all areas, including the Ballenas Trench and Delfin Basin. This is different from the conclusions of Sverdrup (1941) in which it was stated that the water in the northern portion of the Gulf was of local origin and was formed by convective currents in winter. The bottom water here was found to have the same T-S-$O_2$ relationship as water at similar depths south of the Ballenas Sill (Malone, unpublished TE VEGA cruise 16 manuscript).

(3) Intermediate Water. The deep water south of the Ballenas Sill is characteristic of the Intermediate Water found throughout the rest of the Eastern Tropical Pacific.

(4) Pacific Deep Water. In the deep portions of the southern Gulf the waters are characteristic of Pacific Deep Water.

B. EUPHAUSIIDS

1. General

The order Euphausiacea belongs to the phylum Arthropoda, the class Malacostraca, and the superorder Eucarida (Ricketts and Calvin, 1968). It is composed of two families, the Bentheuphausiidae and the Euphausiidae (Boden *et al*, 1955).

All taxonomic descriptions that follow have been condensed from Boden *et al*, (1955) and Banner (1949).

2. Terminology

Figure 10 presents a diagram of a composite euphausiid and is intended as a key to the structures and terms used in the taxonomy of the Euphausiacea. The euphausiid body is readily separated into a larger anterior part called the cephalothorax and a more slender posterior part called the abdomen. The cephalothorax is covered by a well developed carapace which coalesces dorsally with all thoracic segments, the anterior part of which is usually triangular, when viewed from above, and is called the frontal plate. This may be produced anteriorly, over or between the eyes, as a rostrum that can vary in size and shape. Below the paired eyes, which are well developed and on movable stalks, are the peduncles of the first antennae, each with two flagella attached. The peduncles of the second antennae

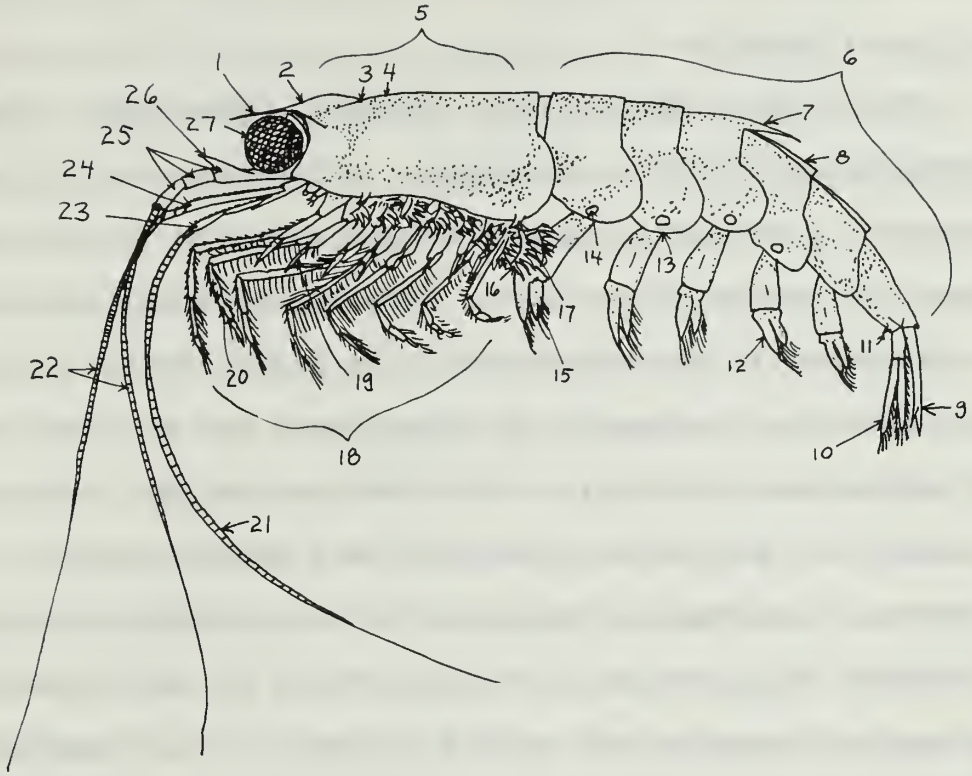



Figure 10. Diagram of euphausiid, illustrating terminology. (1) rostrum, (2) frontal plate, (3) cervical groove, (4) carapace, (5) cephalothorax, (6) abdomen, (7) dorsal tooth (spine), (8) dorsal keel, (9) telson, (10) uropod, (11) preanal spine of sixth abdominal segment, (12) pleopod, one of 5 pairs, (13) pleuron, (14) luminescent organ, (15) male copulatory organ, (16) gills, (17) lateral denticle (spine), (18) thoracic appendage, (19) exopodite of first thoracic appendage, (20) endopodite (thoracic leg) of second thoracic appendage, (21) flagellum of second antenna, (22) flagella of first antenna, (23) peduncle of second antenna, (24) scale or squama, (25) peduncle of first antenna, (26) lappet on first segment of peduncle, (27) eye. (After Boden et al, (1955))

carry one flagellum each along with a scale or squama. The mouth-parts consist of labrum, labia, mandibles, and two pairs of maxillae.

There are eight pairs of thoracic appendages. The endopodites of these appendages, which are usually long as compared with their expodites, are referred to as thoracic legs. Attached to the outer side of the joint common to both exopodite and endopodite of a given leg is a gill. The abdominal segments, of which there are six, may carry a median keel dorsally. This keel may or may not be extended in a posterior direction as a dorsal tooth or process. Laterally, the edges of each abdominal segment projects as a pleuron. The appendages of the first five abdominal segments are called pleopods. The endopodites of the first and second pleopods are modified to form the male copulatory organs. They are of considerable taxonomic importance for many species but not for any of the ones described herein. Hence they will not be mentioned here again. The last abdominal segment terminates in the telson. This telson bears a biramous uropod on either side.

All genera except Bentheuphausia G. O. Sars have complex thoracic and abdominal luminescent organs.

The lengths given below are measured from the tip of the rostrum to the tip of the telson.

This paper deals only with the 13 different species found during the two expeditions described earlier. Of the nearly 43,000 specimens identified, all were from the family Euphausiidae and consisted of the following: *Euphausia diomedeae*, *E. distinguenda*, *E. eximia*, *E. gibboides*, *Nematoscelis difficilis*, *N. gracilis*, *N. tenella*, *Nematobrachion boöpis*, *N. flexipes*, *Nyctiphanes simplex*, *Stylocheiron abbreviatum*, *S. maximum*, and *Thysanopoda orientalis*. Each species is described in a separate section. Following each description is a series of figures. If the species was found during TE VEGA cruise 16 in the Gulf of California a figure showing the horizontal distribution found there is presented. If Brinton (1962) reported its presence in the Gulf, his horizontal distribution is shown in the following figure for comparison. If the species was found during TE VEGA cruises 16 or 17 in the Eastern Tropical Pacific a figure showing the horizontal distribution found there is presented next. Again, if Brinton (1962) reported its presence in this area his horizontal distribution is shown following for comparison. Following these horizontal distributions are the vertical distributions found during the TE VEGA cruises.

3. Family Euphausiidae Holt and Tattersall, 1905

a. The Genus Euphausia Dana

Generic characters: The rostrum is variable in shape. The anterolateral angles of the carapace are variable. The eyes are spherical and undivided. The first antennal peduncle is normally alike in both sexes, sometimes showing sexual dimorphism. The basal segment of the peduncle carries a small lappet at the distal end in some species. Both flagella are elongate and consist of numerous segments. The terminal article of the maxilla is broad and the exopodite small. The seventh and eighth thoracic legs are rudimentary in both sexes with the endopodites lacking.

The genus is the largest of the order. It contains 29 or 30 known species at present. The four species encountered are described here.

(1) Euphausia diomedeae Ortmann. The short frontal plate bears a slender rostrum. The frontal plate is occasionally broadly expanded over the eyestalks. A bifid lobe pointing forward and outward is carried on the upper anterior margin of the basal segment of the first antennal peduncle. The base of this lobe is a little wider than half the width of the basal segment. The upper distal end of the second segment carries two processes, the outer of which is blunt and the inner spiniform. A short low keel is carried on the third segment. The carapace has two lateral denticles. The abdominal segments are unarmed.

Length: 12 to 17.5 mm.

Depth varies from the surface to 500 meters for adults and surface to 200 meters for larvae.

A total of 519 specimens were found in two trawls, both in the Eastern Tropical Pacific (see Figures 12-14).

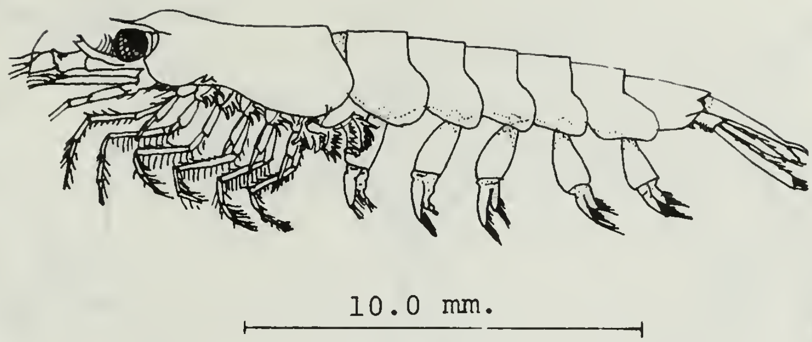



Figure 11. Euphausia diomedeae Ortmann. Adult male. (After Boden et al, (1955))

(2) Euphausia distinguenda Hansen. Frontal plate is narrow. Rostrum is acute, short and poorly defined. Eyes are small. The lateral process on the inferior margin of the carapace is located toward the posterior end. A long, compressed, and spiniform dorsal process is borne on the third abdominal segment. The basal segment of the first antennal peduncle is slightly raised distally but lacks true lobes or processes. Its anterior margin is concave. A short oblique keel is carried on the second segment. It ends distally in an upward- and forward- projecting rounded process. A high, rounded keel is borne on the distal half of the third segment.

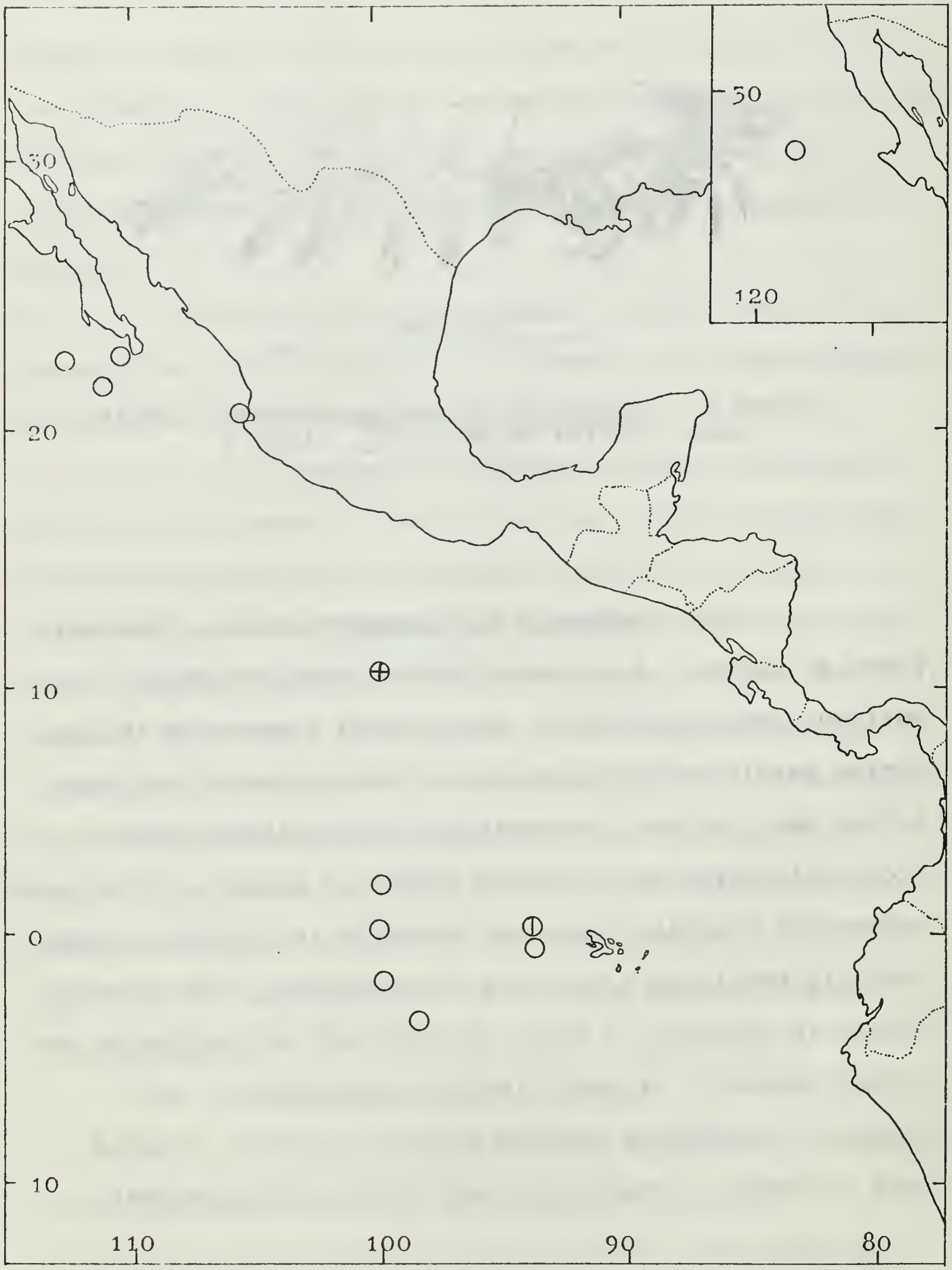



Figure 12. Horizontal Distribution of Euphausia diomedeae in the Eastern Tropical Pacific

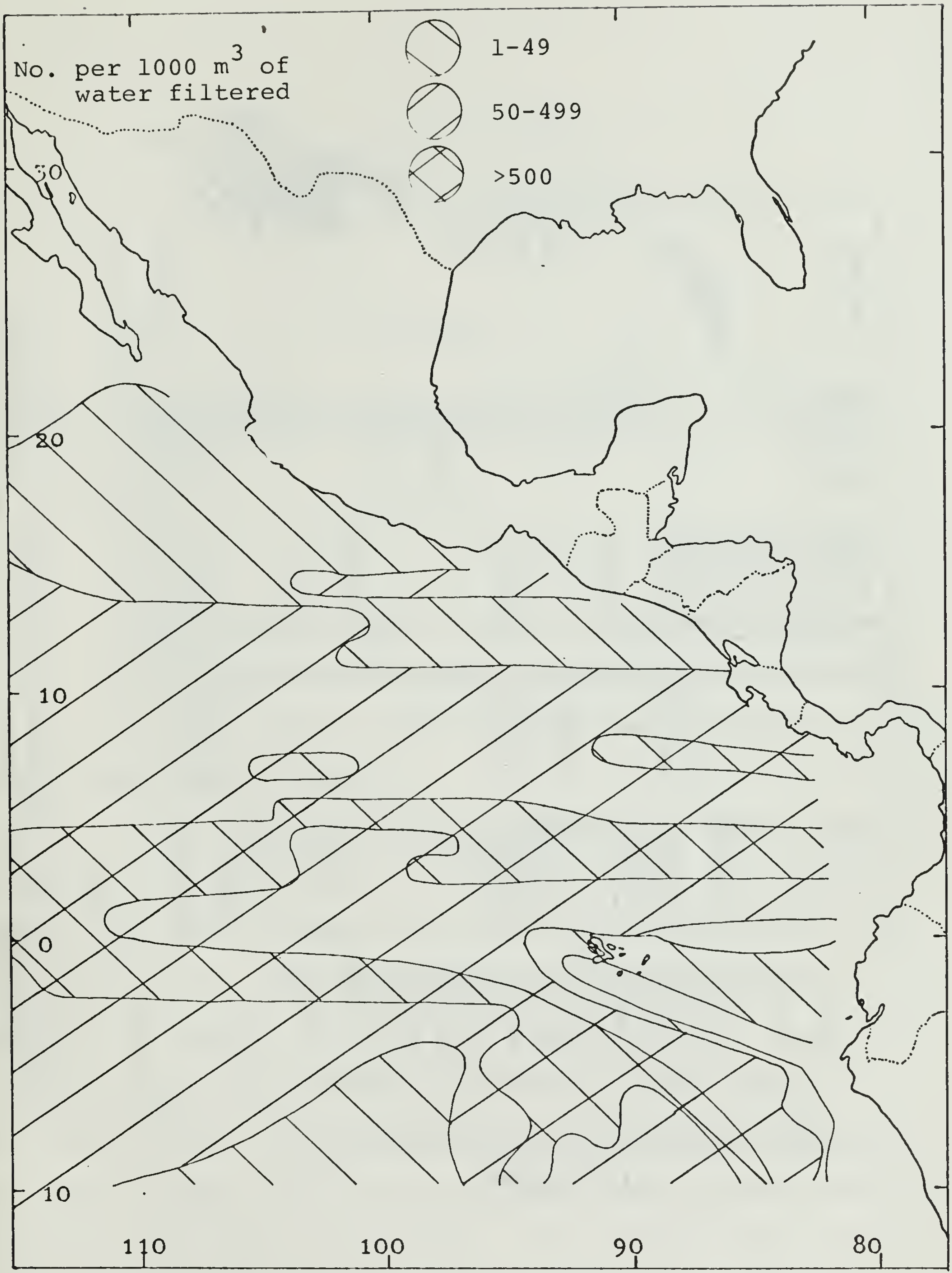



Figure 13. Horizontal Distribution of Euphausia diomedeae in the Eastern Tropical Pacific found by Brinton. (After Brinton, (1962)).

| DEPTH (m) | DAY | NIGHT |
|---|---|---|
| 0-50 | NO DATA | 17-003○ 17-020⊕ 17-044○ 17-026○ 17-028○ 16-188○ 16-190○ |
| 50-100 | 17-016○ | 17-051○ |
| 100-150 | 17-050○ | 17-019○ 17-068○ |
| 150-200 | 17-058○ 17-060○ 17-061○ | 17-035○ 17-062○ |
| 200-250 | 17-010○ 17-015○ 17-040○ 17-041○ 16-191○ | 17-037○ |
| 250-300 | 17-008○ 17-070○ 16-193○ | 17-007○ |
| 300-350 | 17-047○ 17-048○ 17-066○ 17-069○ 17-072○ | 17-067○ |
| 350-400 | 17-032○ 17-042○ 17-043○ 17-057○ 16-184○ | 17-038○ |
| 400-450 | 17-017○ 17-071⦶ | NO DATA |
| 450-500 | 17-049○ | NO DATA |
| 500-550 | 17-059○ | 17-027○ |
| 550-600 | 17-018○ | 17-036○ |
| OTHERS | 1000-1050 17-031○ 16-192○<br>2000-2050 17-065○ | 650-700 16-186○<br>750-800 16-189○<br>1000-1050 17-029○ 17-064○<br>UNKNOWN DEPTH 17-055○ |

Figure 14. Diurnal Vertical Distribution of Euphausia diomedeae in the Eastern Tropical Pacific

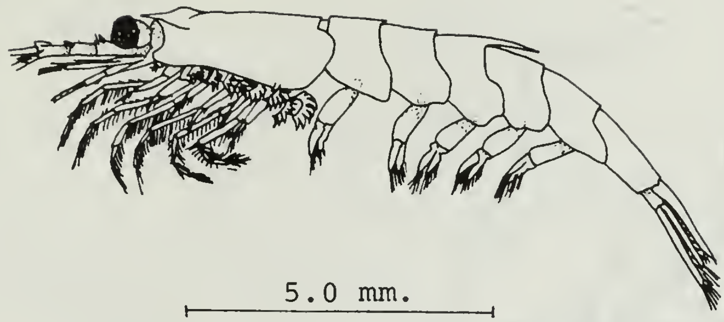


Figure 15. Euphausia distinguenda Hansen. Adult male. (After Boden et al, (1955)).

Length: about eight to eight and a half mm.

Adults and larvae are found above 400 meters.

A total of 4956 specimens were found in 27 trawls (see Figures 16-21).

(3) Euphausia eximia Hansen. The frontal plate is short, triangular, with a prominent, slender rostrum. The vaulted gastric region has a high keel reaching out onto the rostrum. The upper margin of the keel may be angular. The eyes are medium sized and spherical. The peduncle of the first antenna is similar in both sexes. The first segment is almost as long as both of the other two, and is armed dorsally on the distal end with an almost vertical transverse lobe or plate. The anterior margin of this plate has a pectinate appearance due to the presence of about 12 spiniform processes. The second segment is

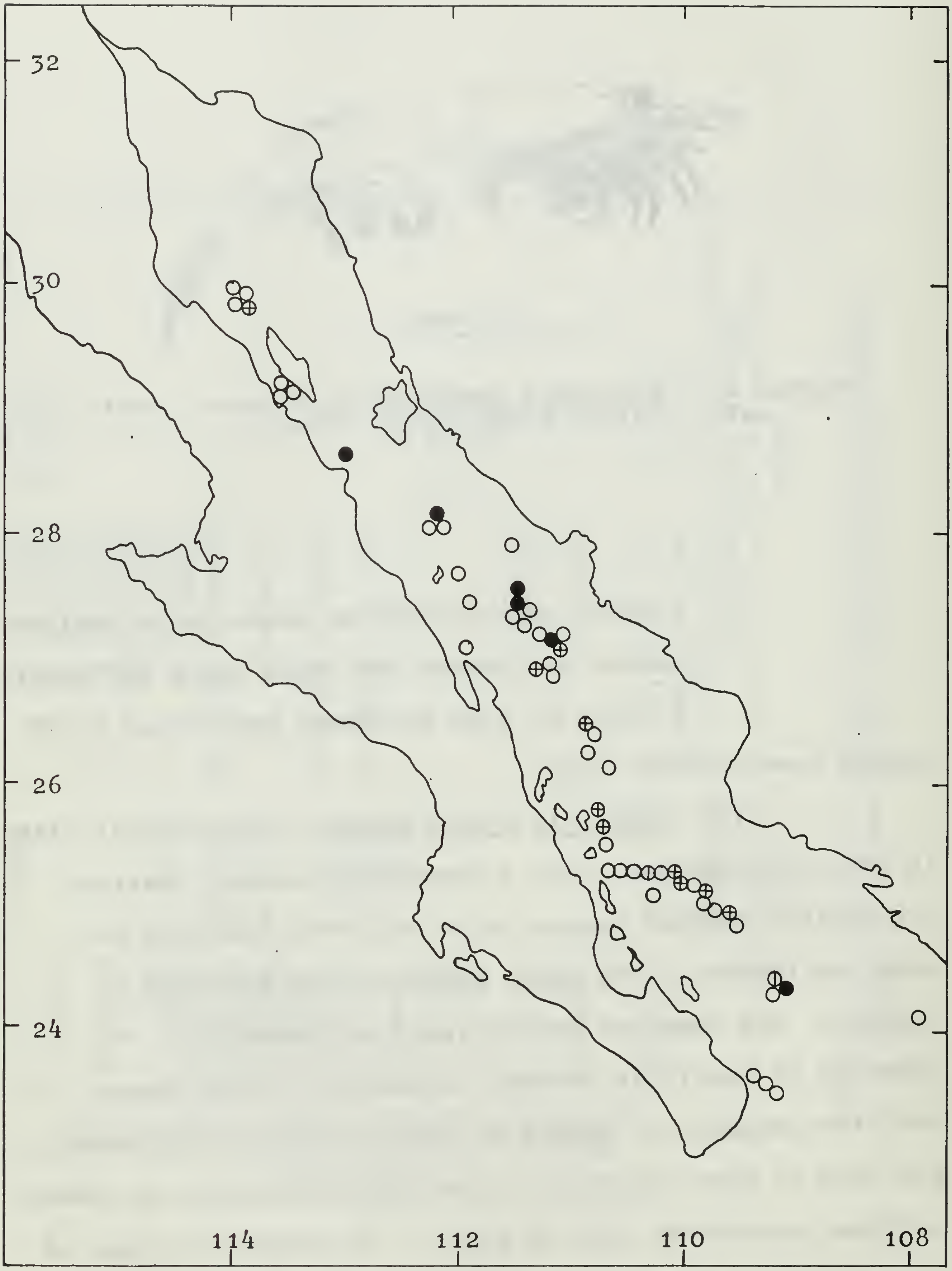



Figure 16. Horizontal Distribution of Euphausia distinguenda in the Gulf of California

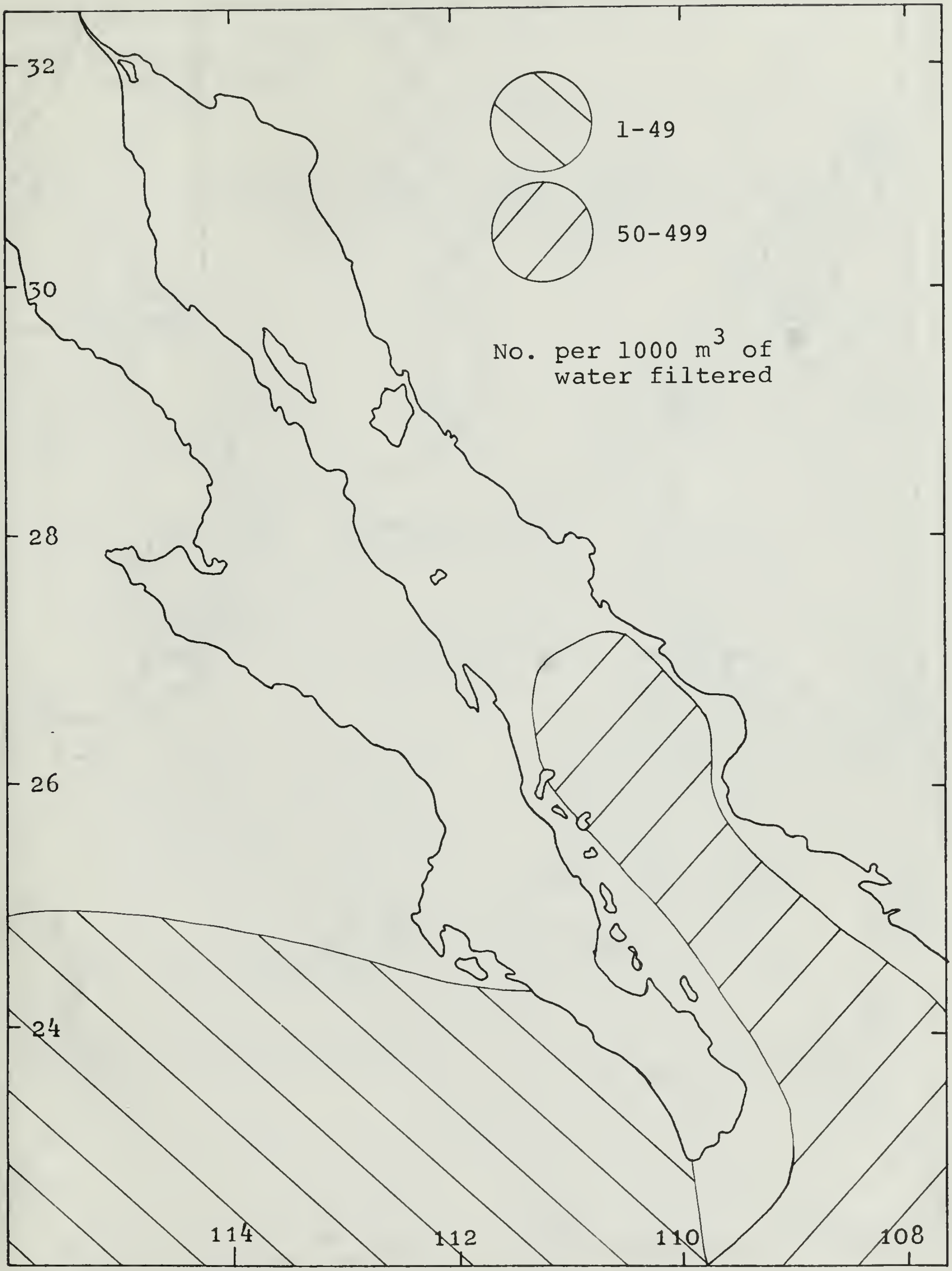



Figure 17. Horizontal Distribution of <u>Euphausia distinguenda</u> in the Gulf of California found by Brinton. (After Brinton, (1962))


Figure 18. Horizontal Distribution of <u>Euphausia distinguenda</u> in the Eastern Tropical Pacific

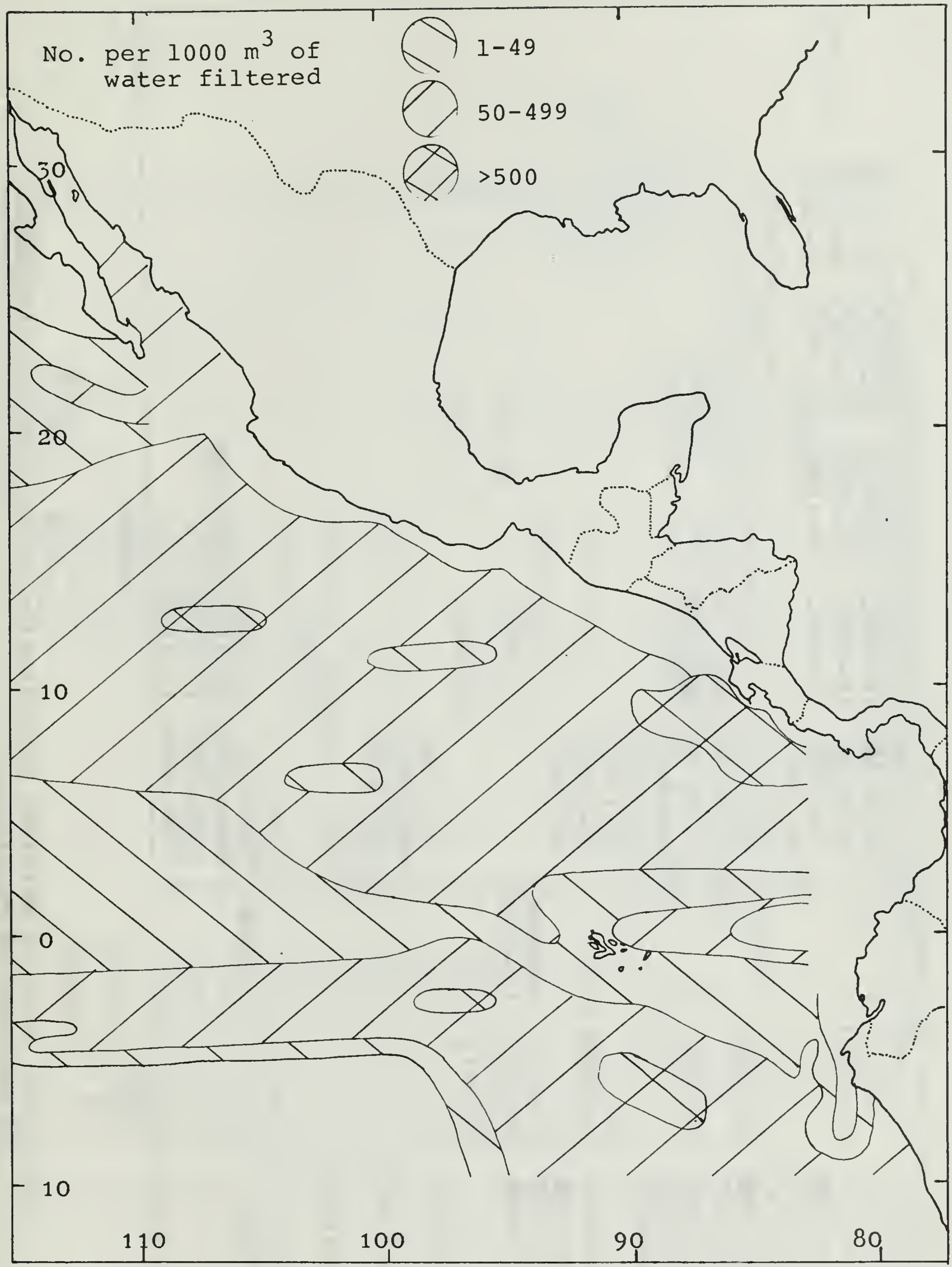



Figure 19. Horizontal Distribution of Euphausia distinguenda in the Eastern Tropical Pacific found by Brinton. (After Brinton, (1962))

| DEPTH (m) | DAY | | | NIGHT | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| 0- | 16-012○ | 16-140○ | | 16-021● | 16-022○ | 16-061○ | 16-083○ | 16-113⊕ | |
| 50 | 16-094○ | | | 16-21A● | 16-056○ | 16-067○ | 16-102○ | 16-127⊕ | |
| 50- | 16-124○ | 16-169○ | | 16-033○ | 16-084○ | 16-095⊕ | 16-119○ | 16-131○ | 16-139○ |
| 100 | 16-138● | | | 16-039⊕ | 16-090○ | 16-114○ | 16-126○ | 16-132○ | |
| 100- | 16-063○ | | | 16-156○ | | | | | |
| 150 | 16-163○ | | | | | | | | |
| 150- | 16-074● | 16-137○ | | 16-148○ | | | | | |
| 200 | 16-121○ | | | | | | | | |
| 200- | 16-19A⦶ | 16-122○ | | 16-091○ | 16-178○ | | | | |
| 250 | 16-087○ | | | 16-152○ | | | | | |
| 250- | 16-161⊕ | | | 16-118○ | | | | | |
| 300 | | | | 16-125○ | | | | | |
| 300- | 16-062○ | 16-136● | | 16-157○ | | | | | |
| 350 | 16-135● | | | 16-166○ | | | | | |
| 350- | 16-035⊕ | 16-111○ | 16-160○ | | NO DATA | | | | |
| 400 | 16-064● | 16-145○ | 16-162⊕ | | | | | | |
| 400- | | NO DATA | | | NO DATA | | | | |
| 450 | | | | | | | | | |
| 450- | 16-088○ | | | 16-165⊕ | | | | | |
| 500 | | | | 16-180○ | | | | | |
| 500- | 16-144⊕ | | | 16-158○ | | | | | |
| 550 | | | | | | | | | |
| 550- | 16-123○ | | | | NO DATA | | | | |
| 600 | | | | | | | | | |
| | OTHERS | 850-900 | 16-112● | 600-650 | 16-179○ | | | | |
| | | | | 1000-1050 | 16-167○ | 16-168⊕ | | | |
| | | | | 1450-1500 | 16-147○ | | | | |
| | | | | 2250-2280 | 16-159⦶ | | | | |

Figure 20. Diurnal Vertical Distribution of Euphausia distinguenda in the Gulf of California

| DEPTH (m) | DAY | | | NIGHT | | |
|---|---|---|---|---|---|---|
| 0-50 | NO DATA | | | 17-003○<br>17-020● | 17-026○<br>17-028○ | 16-190⊕ |
| 50-100 | 17-016○ | | | 17-044○<br>17-051○ | 16-188● | |
| 100-150 | 17-050○ | | | 17-019⦶<br>17-068○ | | |
| 150-200 | 17-058○<br>17-060○ | 17-061○ | | 17-035○<br>17-062○ | | |
| 200-250 | 17-010○<br>17-015○ | 17-040○<br>17-041○ | 16-191○ | 17-037○ | | |
| 250-300 | 17-008○<br>17-070○ | 16-193⊕ | | 17-007○ | | |
| 300-350 | 17-047○<br>17-048○ | 17-066○<br>17-069○ | 17-072⊕ | 17-067○ | | |
| 350-400 | 17-032○<br>17-042○ | 17-043○<br>17-057○ | 16-184○ | 17-038○ | | |
| 400-450 | 17-017○<br>17-071○ | | | | NO DATA | |
| 450-500 | 17-049○ | | | | NO DATA | |
| 500-550 | 17-059○ | | | 17-027○ | | |
| 550-600 | 17-018○ | | | 17-036○ | | |
| | OTHERS | 1000-1050<br><br>2000-2050 | 17-031○<br>16-193⊕<br>17-065○ | 650-700<br>750-800<br>1000-1050<br>UNKNOWN DEPTH | 16-186○<br>16-189○<br>17-029○<br>17-055○ | <br><br>17-064○ |

Figure 21. Diurnal Vertical Distribution of *Euphausia distinguenda* in the Eastern Tropical Pacific

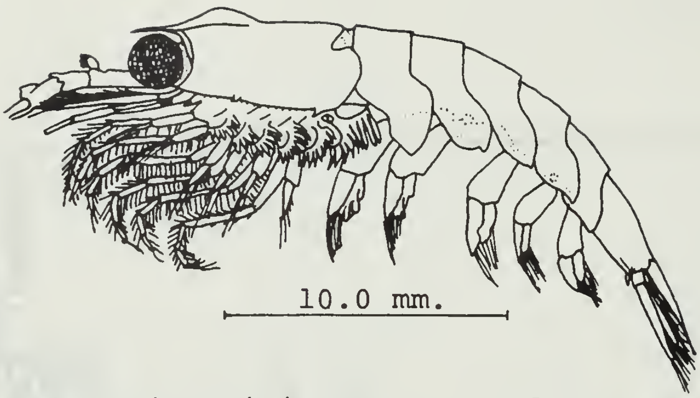



Figure 22. Euphausia eximia Hansen. Adult male. (After Boden et al, (1955))

slightly longer than the third. Two prominent, somewhat curved, forward-projecting protuberances are borne on the dorsal side of its margin. The inner protuberance may be bifurcate. A keel or lamella is carried dorsally on the terminal segment. This keel has a concave anterior margin and is about two-thirds as long as the segment. Its uppermost part ends as a small tooth. The second antennal scale reaches about to the middle of the third segment of the first antennal peduncle. The second antennal peduncle outer spiniform process is about half as long as the scale.

Length: about 16-20 mm.

Depths for adults range from the surface to 500 m.; larvae above 150 m.

A total of 30,936 specimens were found in 83 trawls (see Figures 23-28).

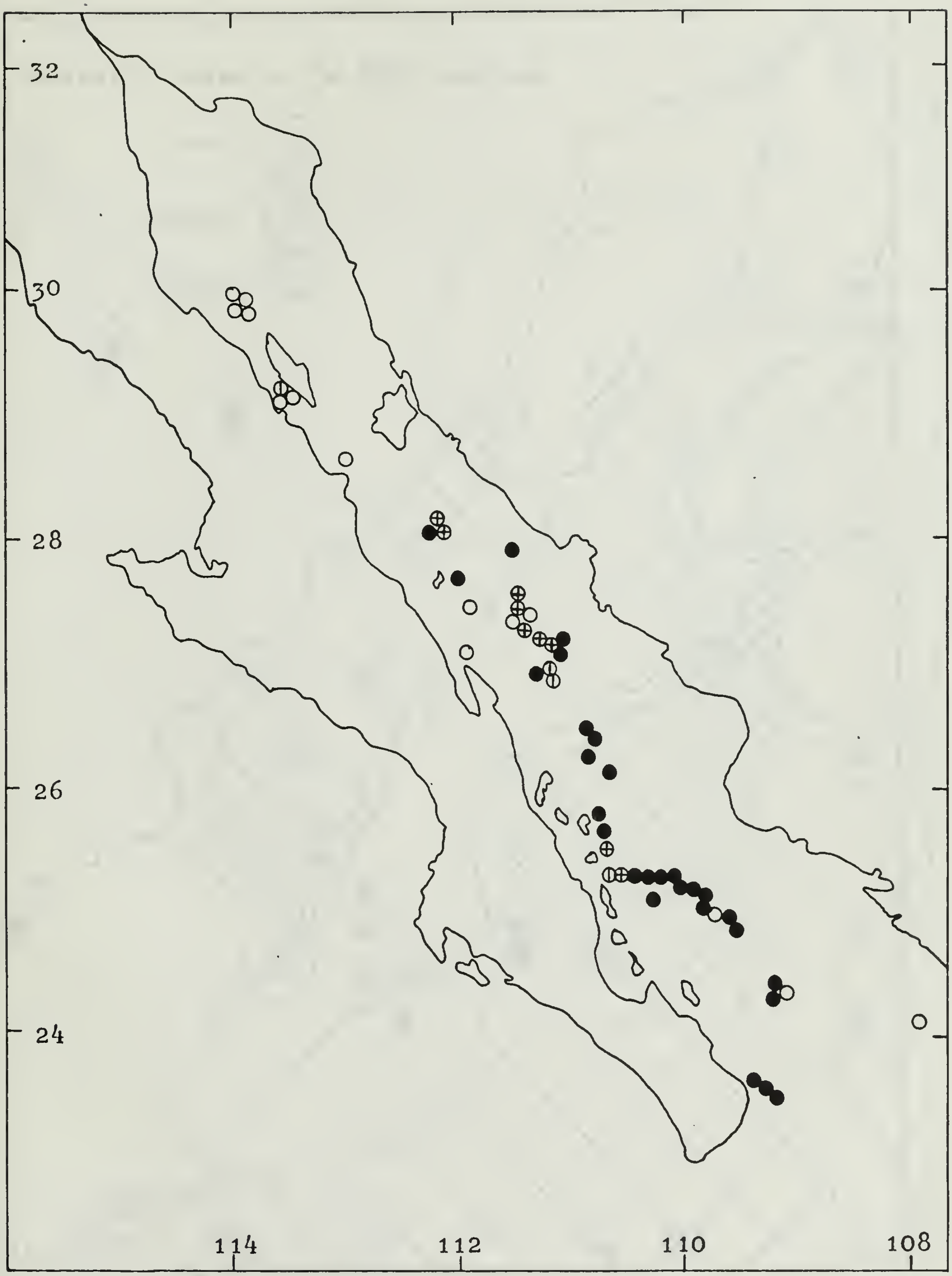



Figure 23. Horizontal distribution of <u>Euphausia eximia</u> in the Gulf of California.

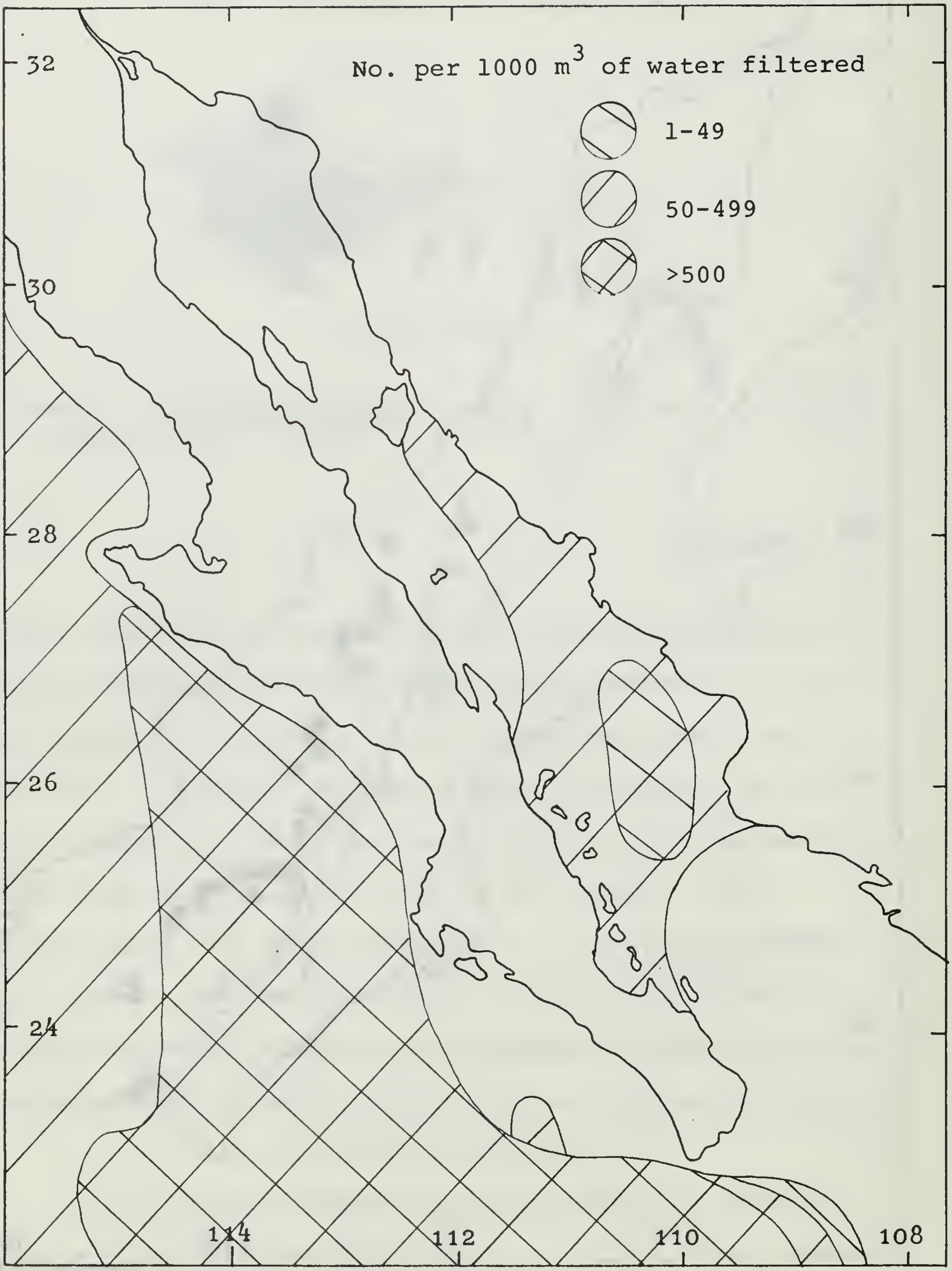



Figure 24. Horizontal Distribution of *Euphausia eximia* in the Gulf of California found by Brinton. (After Brinton, (1962))

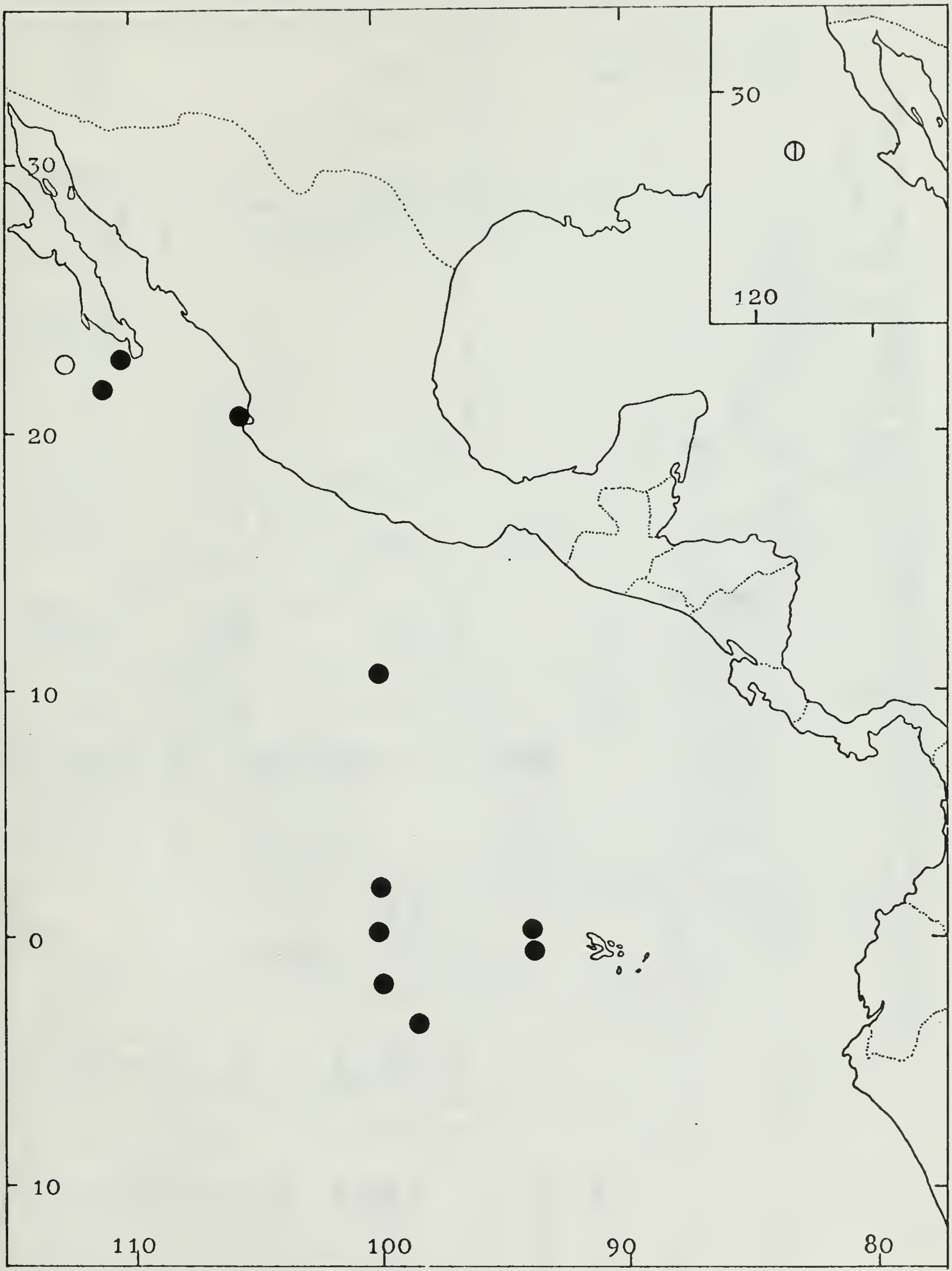



Figure 25. Horizontal Distribution of *Euphausia eximia* in the Eastern Tropical Pacific

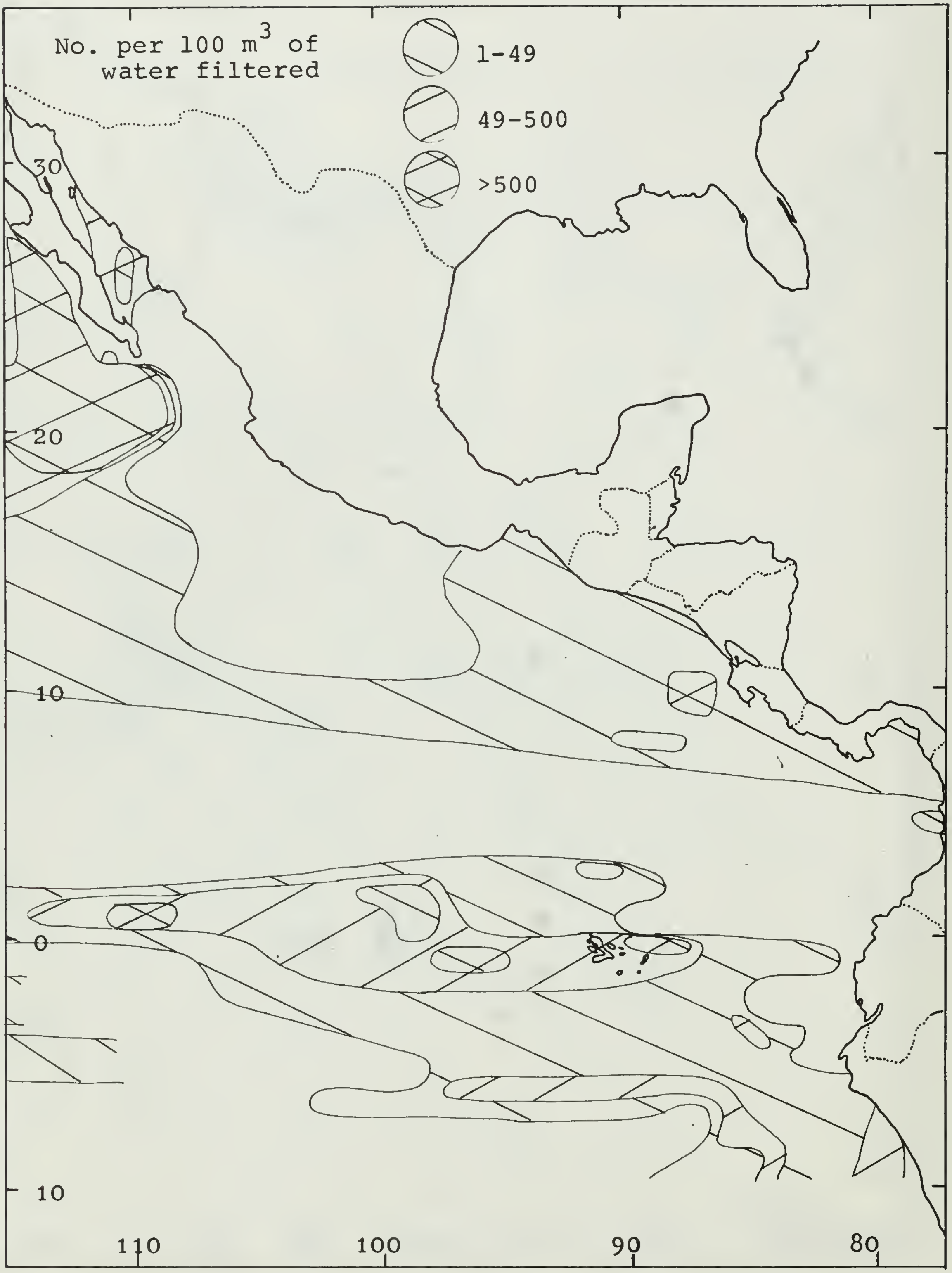


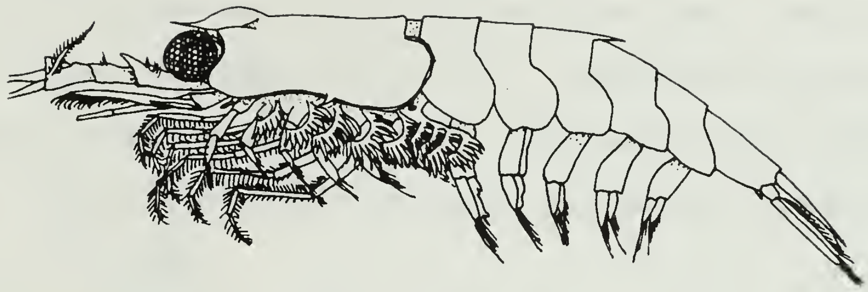

Figure 26. Horizontal Distribution of <u>Euphausia eximia</u> in the Eastern Tropical Pacific found by Brinton. (After Brinton, (1962))

| DEPTH (m) | DAY | NIGHT |
| --- | --- | --- |
| 0-50 | 16-012○ 16-140○ 16-094○ | 16-021○ 16-022● 16-061○ 16-083⦶ 16-113● 16-21A○ 16-056● 16-067● 16-102● 16-127● |
| 50-100 | 16-124○ 16-169● 16-138○ | 16-033● 16-084○ 16-095○ 16-119⦶ 16-131⦶ 16-139○ 16-039● 16-090○ 16-114⊕ 16-126● 16-132⊕ |
| 100-150 | 16-063⊕ 16-163● | 16-156⦶ |
| 150-200 | 16-074○ 16-137○ 16-121○ | 16-148● |
| 200-250 | 16-19A● 16-122○ 16-087○ | 16-091○ 16-178● 16-152⊕ |
| 250-300 | 16-161● | 16-118⦶ 16-125⊕ |
| 300-350 | 16-062● 16-136⊕ 16-135⊕ | 16-157⊕ 16-166● |
| 350-400 | 16-035● 16-111● 16-160● 16-064⊕ 16-145● 16-162● | NO DATA |
| 400-450 | NO DATA | NO DATA |
| 450-500 | 16-088○ | 16-165● 16-180● |
| 500-550 | 16-144● | 16-158● |
| 550-600 | 16-123● | NO DATA |
| OTHERS | 850-900 16-112⊕ | 600-650 16-179●<br>1000-1050 16-167○ 16-168●<br>1450-1500 16-147●<br>2250-2280 16-159● |

Figure 27. Diurnal Vertical Distribution of Euphausia eximia in the Gulf of California

| DEPTH (m) | DAY | | | NIGHT | | |
|---|---|---|---|---|---|---|
| 0-50 | NO DATA | | | 17-003⦶ | 17-026○ | 16-190● |
| | | | | 17-020⦶ | 17-028○ | |
| 50-100 | 17-016○ | | | 17-044● | 16-188⊕ | |
| | | | | 17-051● | | |
| 100-150 | 17-050○ | | | 17-019● | | |
| | | | | 17-068⦶ | | |
| 150-200 | 17-058⊕ | 17-061○ | | 17-035⦶ | | |
| | 17-060○ | | | 17-062● | | |
| 200-250 | 17-010● | 17-040○ | 16-191● | 17-037○ | | |
| | 17-015○ | 17-041○ | | | | |
| 250-300 | 17-008● | 16-193● | | 17-007○ | | |
| | 17-070○ | | | | | |
| 300-350 | 17-047● | 17-066● | 17-072● | 17-067● | | |
| | 17-048○ | 17-069● | | | | |
| 350-400 | 17-032○ | 17-043● | 16-184● | 17-038⊕ | | |
| | 17-042● | 17-057● | | | | |
| 400-450 | 17-017○ | | | | NO DATA | |
| | 17-071⊕ | | | | | |
| 450-500 | 17-049○ | | | | NO DATA | |
| 500-550 | 17-059⦶ | | | 17-027● | | |
| 550-600 | 17-018○ | | | 17-036● | | |
| | OTHERS | 1000-1050 | 17-031● | 650-700 | 16-186● | |
| | | | 16-192● | 750-800 | 16-189● | |
| | | 2000-2050 | 17-065○ | 1000-1050 | 17-029● | 17-064● |
| | | | | UNKNOWN DEPTH | 17-055● | |

Figure 28. Diurnal Vertical Distribution of Euphausia eximia in the Eastern Tropical Pacific



10.0 mm.

Figure 29. Euphausia gibboides Ortmann. Adult male. (After Boden et al, (1955))

(4) Euphausia gibboides Ortmann. The fairly thickset body has a short frontal plate which is produced into a rostrum that is broad at the base but spiniform distally. The rostrum is projected at a variable vertical angle. The gastric region has a conspicuous keel. The inferior margin of the carapace bears a single lateral denticle. The large eyes are spherical. The first antennal peduncle inner distal margin is produced into a long lobe that projects forward and upward for the first half of its length, beyond which it tapers abruptly and bends sharply outward. The second segment upper distal margin is concave but projects as a lobe over the proximal end of the third segment. The third segment bears a high dorsal keel with the distal edge produced dorsally as a tooth. The second antennal peduncle scale reaches to about

the middle of the third segment of the first antennal peduncle. The outer spiniform process is not quite half as long as the scale. The third abdominal segment bears a short tooth dorsally. The fourth and fifth segments lack dorsal processes. In both sexes the preanal spine is simple.

Length varies from up to 22 mm. in males to up to 27 mm. in females.

Depth for adults is 100 to 500 meters; larvae are found above 200 meters.

A total of 1376 specimens were found in 36 trawls (see Figures 30-34).

b. The Genus Nematoscelis G. O. Sars

Generic characters: The rostrum is variable. The eyes are large and constricted transversely. The first antennal peduncles are elongate and slender in the female, shorter and thicker in the male. The mandibular palps are small. The terminal segments of the first pair of thoracic legs are flattened and pectinate in appearance. The second pair of thoracic legs is very long. Bristles are borne only on the terminal one or two segments. The seventh thoracic leg is lacking in the male, biarticulate in the female. The seventh thoracic appendage exopodite is present in both sexes. The eighth thoracic appendage is a simple setose plate.

The genus contains six known species. The three encountered are described here.

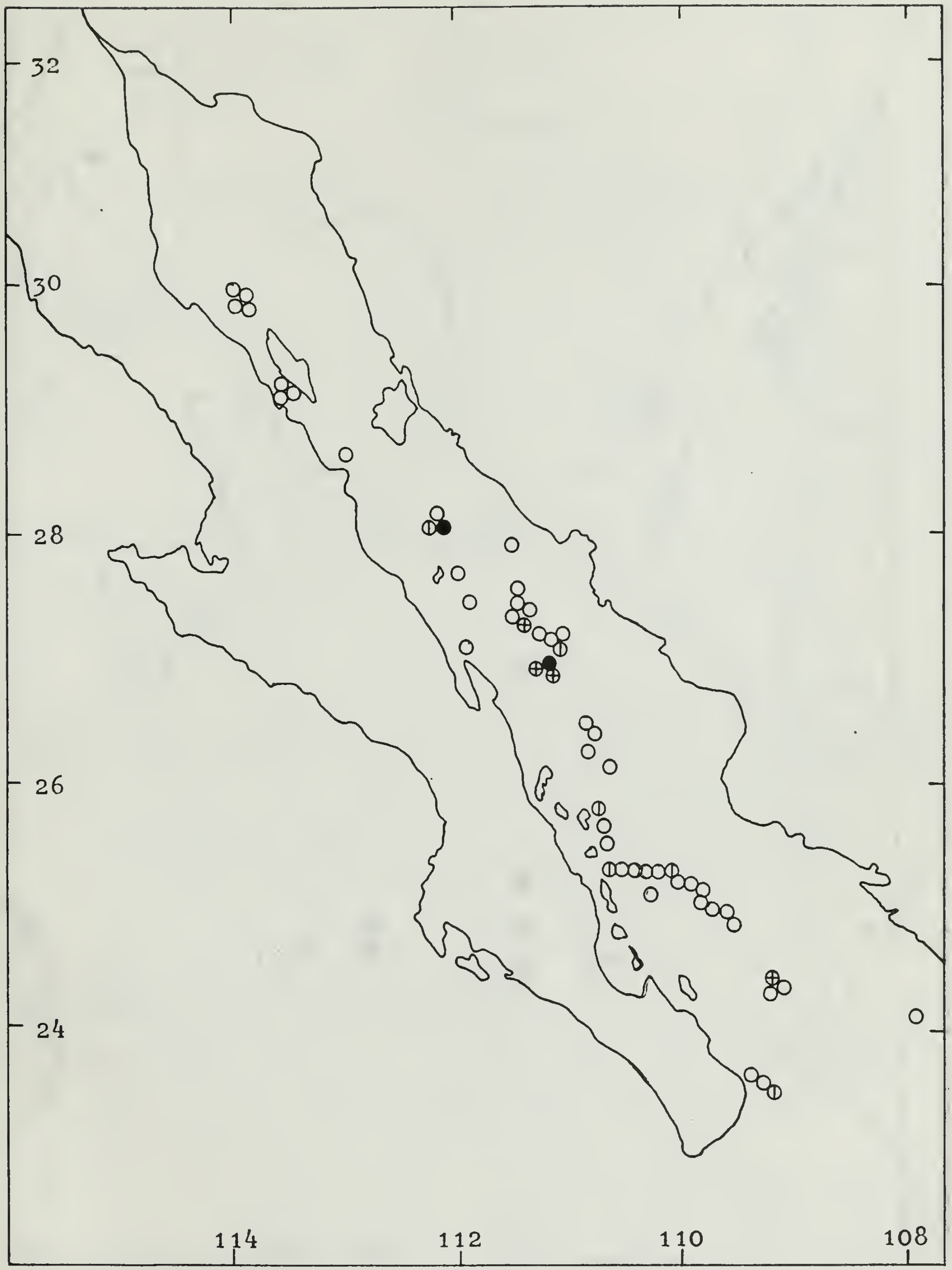



Figure 30. Horizontal Distribution of Euphausia gibboides in the Gulf of California

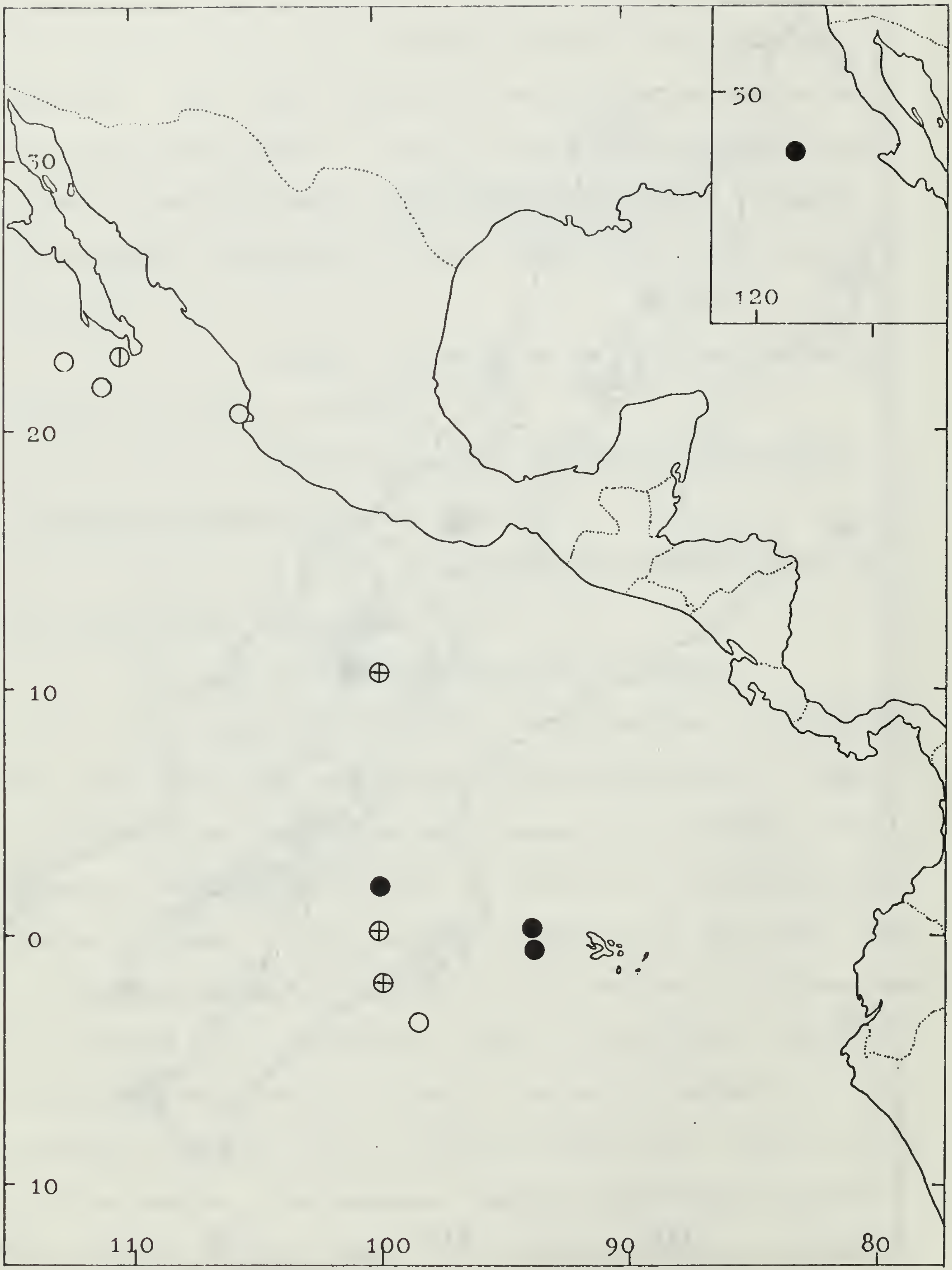



Figure 31. Horizontal Distribution of Euphausia gibboides in the Eastern Tropical Pacific

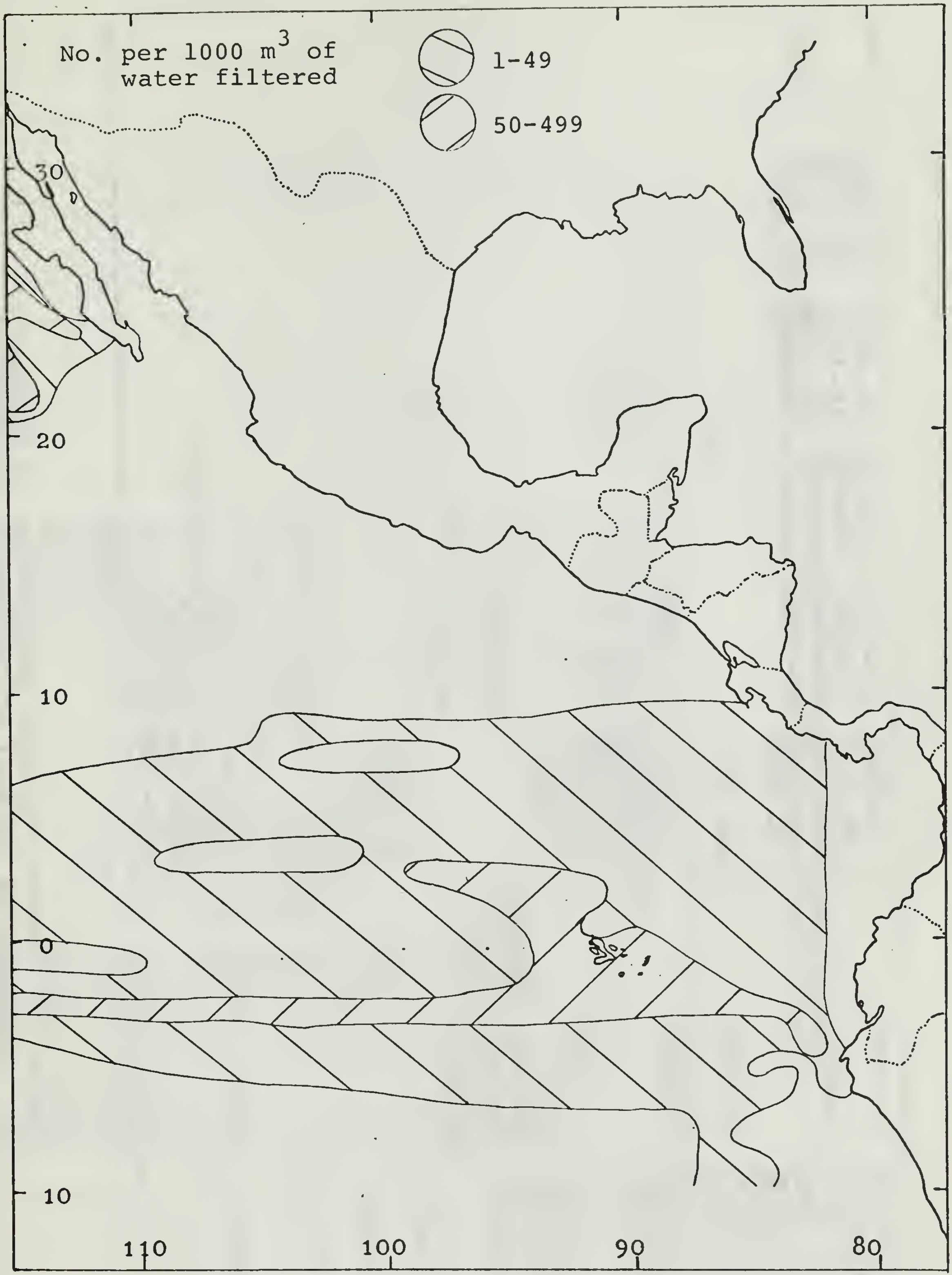



Figure 32. Horizontal Distribution of Euphausia gibboides in the Eastern Tropical Pacific found by Brinton. (After Brinton, (1962))

| DEPTH (m) | DAY | NIGHT |
| --- | --- | --- |
| 0-50 | 16-012○ 16-140○ 16-094○ | 16-021○ 16-022○ 16-061○ 16-083○ 16-113⦶ 16-21A○ 16-056○ 16-067⦶ 16-102○ 16-127○ |
| 50-100 | 16-124○ 16-169○ 16-138○ | 16-033○ 16-084○ 16-095○ 16-119● 16-131⊕ 16-139○ 16-039⦶ 16-090○ 16-114○ 16-126⊕ 16-132○ |
| 100-150 | 16-063● 16-163○ | 16-156⦶ |
| 150-200 | 16-074○ 16-137○ 16-121○ | 16-148○ |
| 200-250 | 16-19A⊕ 16-122⦶ 16-087○ | 16-091○ 16-178○ 16-152○ |
| 250-300 | 16-161⦶ | 16-118⊕ 16-125○ |
| 300-350 | 16-062○ 16-136○ 16-135○ | 16-157○ 16-166○ |
| 350-400 | 16-035○ 16-111○ 16-160○ 16-064○ 16-145○ 16-162○ | NO DATA |
| 400-450 | NO DATA | NO DATA |
| 450-500 | 16-088○ | 16-165○ 16-180⦶ |
| 500-550 | 16-144○ | 16-158○ |
| 550-600 | 16-123○ | NO DATA |
| OTHERS | 850-900 16-112○ | 600-650 16-179○; 1000-1050 16-167○ 16-168○; 1450-1500 16-147○; 2250-2280 16-159○ |

Figure 33. Diurnal Vertical Distribution of Euphausia gibboides in the Gulf of California

| DEPTH (m) | DAY | NIGHT |
|---|---|---|
| 0-50 | NO DATA | 17-003●, 17-026○, 16-190○, 17-020⦶, 17-028○ |
| 50-100 | 17-016○ | 17-044○, 16-188○, 17-051○ |
| 100-150 | 17-050○ | 17-019⊕, 17-068⊕ |
| 150-200 | 17-058●, 17-061○, 17-060○ | 17-035⦶, 17-062⦶ |
| 200-250 | 17-010○, 17-040○, 16-191⦶, 17-015○, 17-041○ | 17-037○ |
| 250-300 | 17-008○, 16-193○, 17-070● | 17-007○ |
| 300-350 | 17-047⊕, 17-066○, 17-072○, 17-048⊕, 17-069⦶ | 17-067○ |
| 350-400 | 17-032⊕, 17-043○, 16-184○, 17-042⊕, 17-057⦶ | 17-038⦶ |
| 400-450 | 17-017○, 17-071⦶ | NO DATA |
| 450-500 | 17-049○ | NO DATA |
| 500-550 | 17-059● | 17-027⊕ |
| 550-600 | 17-018○ | 17-036⊕ |
| OTHERS | 1000-1050: 17-031●, 16-192○; 2000-2050: 17-065○ | 650-700: 16-186○; 750-800: 16-189⦶; 1000-1050: 17-029○, 17-064●; UNKNOWN DEPTH: 17-055○ |

Figure 34. Diurnal Vertical Distribution of <u>Euphausia gibboides</u> in the Eastern Tropical Pacific.

(1) Nematoscelis difficilis Hansen. The thin, long rostral process of the female tapers to an acute point. In the male rostrum shape varies. It is most commonly of an intermediate shape between long and slender, and short and semitriangular. The rostral keel extends backwards over the vaulted gastric area of the carapace. The inferior margin of the carapace bears no lateral denticles. The eyes are about three-fourths as broad as high, with a transverse constriction above the middle. The first antennal peduncles are shorter and thicker in the male than in the female. The dorsal, distal margin of the first segment is produced and setose but bears no lappets or protuberances. The second antennal scale reaches about to the middle of the ultimate segment of the first antennal peduncle. The posterior margin of the flattened final segment of the first thoracic leg bears about ten strong, feathered spines. The second thoracic leg is extremely long and fragile. The distal end of its meral segment reaches beyond the end of the peduncle of the first antenna. The geniculate bend is followed by the three terminal segments. The last is extremely short. The distal end of the penultimate segment carries a group of bristles, and the short dactylus carries numerous similar bristles. The following thoracic legs are thick and short. The endopodite of the seventh thoracic appendage is lacking in the male and consists of two segments in the female. The eithth thoracic appendage is rudimentary. This species

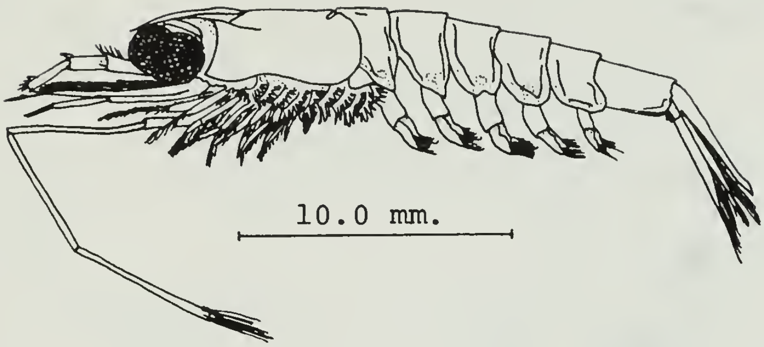



Figure 35. Nematoscelis difficilis Hansen. Adult male. (After Boden et al, 1955).

differs from the Atlantic species N. megalops by structure of the male copulatory organ only.

Length: 22-25 mm.

Adults are occasionally found above 100 meters; larvae 200 meters to the surface.

A total of 1701 specimens were found in 34 trawls (see Figures 36-38).

(2) Nematoscelis gracilis Hansen. The male rostrum is slightly more pronounced than the female, and the frontal plate is narrower. The rostrum rarely extends beyond the mid-point of the eyes. The lateral margins of the carapace lack denticles, although Hansen (1910) reports rudimentary denticles on the males. The upper part of the eye is bent somewhat forward. The male first antennal peduncle is shorter and more robust than the female.

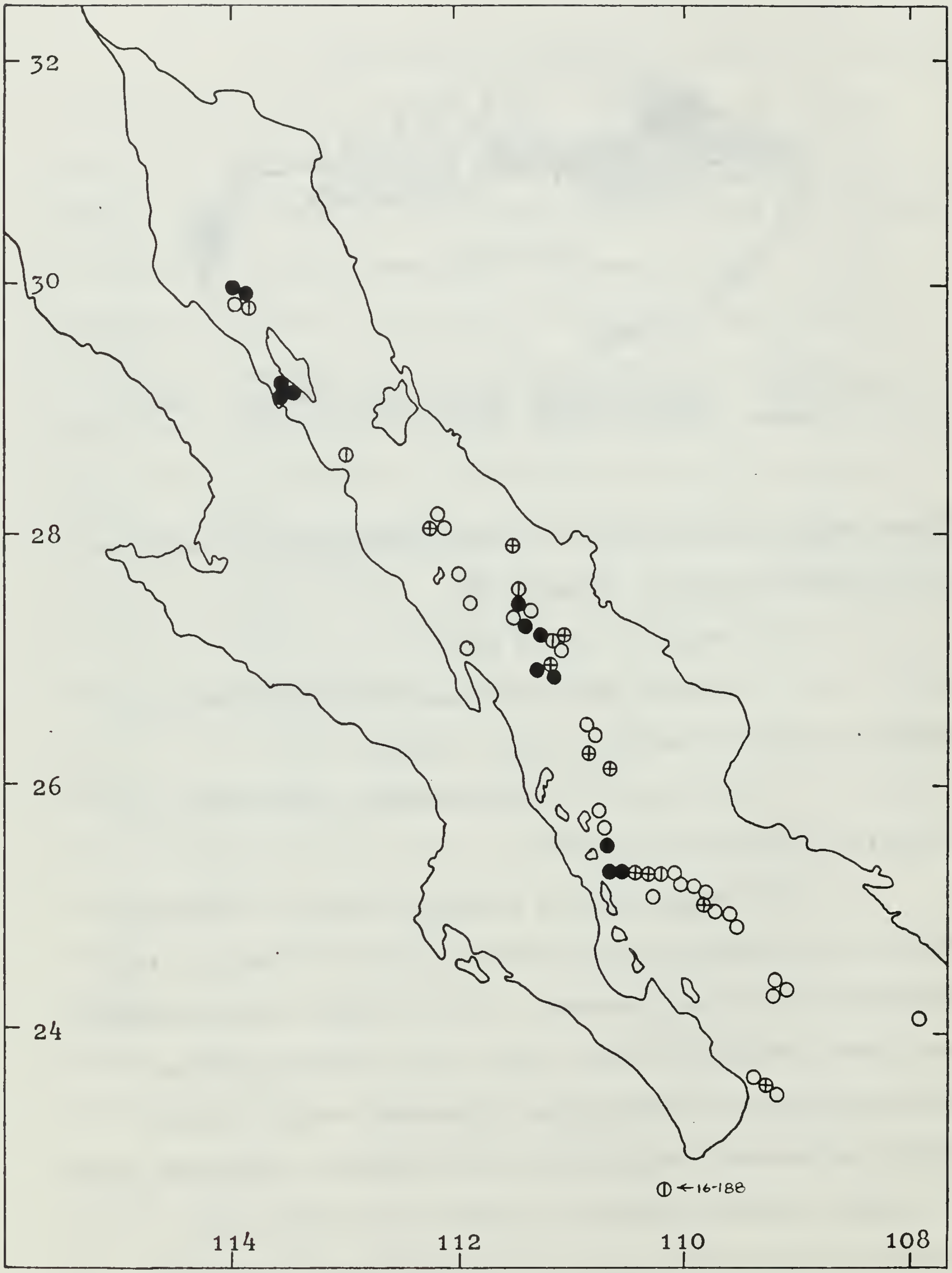



Figure 36. Horizontal Distribution of Nematoscelis difficilis in the Gulf of California

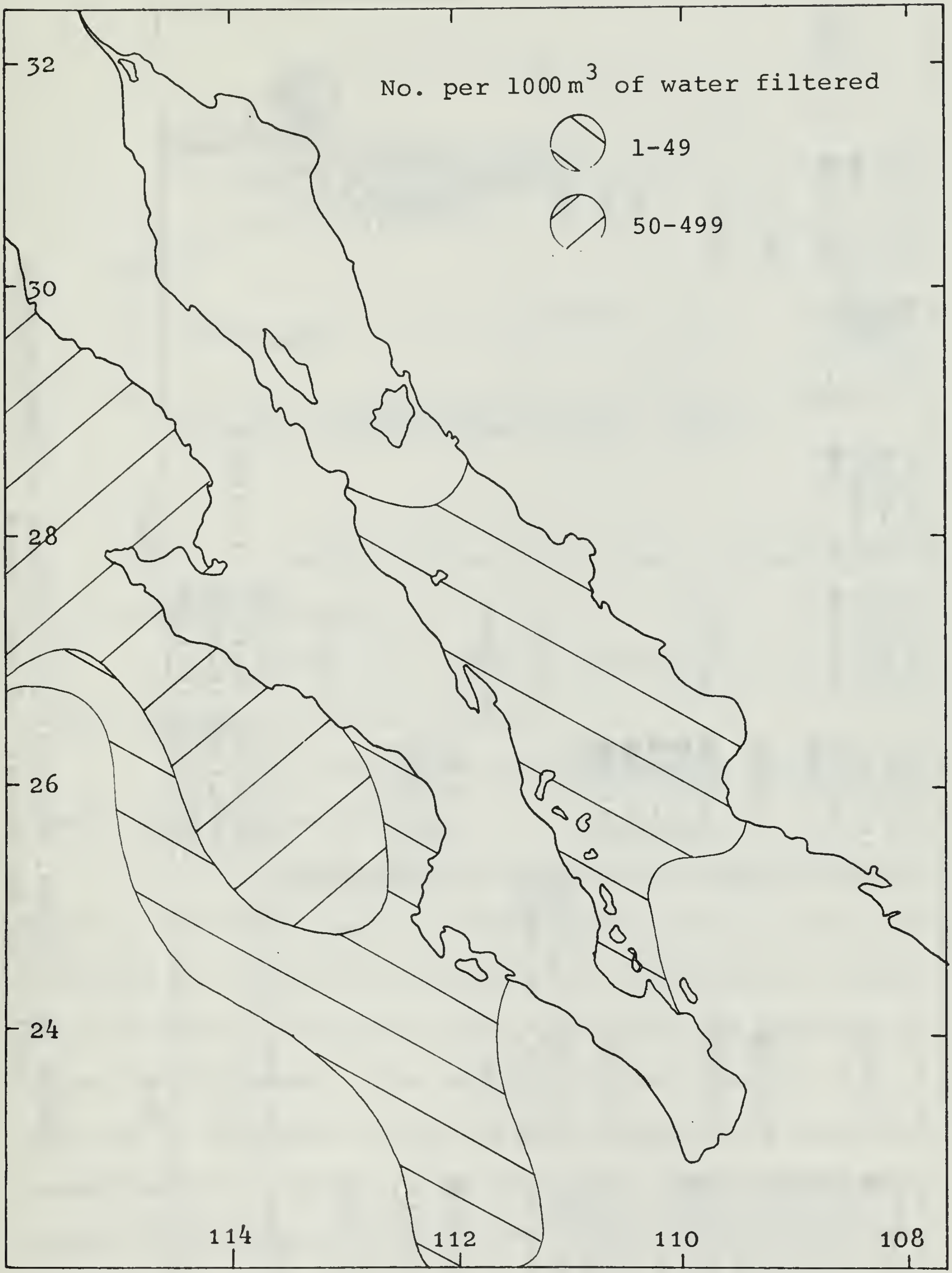



Figure 37. Horizontal Distribution of Nematoscelis difficilis in the Gulf of California found by Brinton. (After Brinton, (1962))

| DEPTH (m) | DAY | | | NIGHT | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| 0- | 16-012○ | 16-140○ | | 16-021○ | 16-022○ | 16-061○ | 16-083● | 16-113○ | |
| 50 | 16-094○ | | | 16-21Λ○ | 16-056○ | 16-067⊕ | 16-102⊕ | 16-127○ | |
| 50- | 16-124● | 16-169○ | | 16-033○ | 16-084○ | 16-095⦶ | 16-119⊕ | 16-131● | 16-139○ |
| 100 | 16-138○ | | | 16-039○ | 16-090● | 16-114● | 16-126⦶ | 16-132● | 16-188⦶ |
| 100- | 16-063○ | | | 16-156● | | | | | |
| 150 | 16-163○ | | | | | | | | |
| 150- | 16-074⦶ | 16-137● | | 16-148⊕ | | | | | |
| 200 | 16-121○ | | | | | | | | |
| 200- | 16-19Λ○ | 16-122⊕ | | 16-091● | 16-178○ | | | | |
| 250 | 16-087● | | | 16-152● | | | | | |
| 250- | 16-161○ | | | 16-118● | | | | | |
| 300 | | | | 16-125● | | | | | |
| 300- | 16-062○ | 16-136⦶ | | 16-157● | | | | | |
| 350 | 16-135⦶ | | | 16-166⊕ | | | | | |
| 350- | 16-035○ | 16-111⊕ | 16-160⦶ | | NO DATA | | | | |
| 400 | 16-064○ | 16-145○ | 16-162○ | | | | | | |
| 400- | | NO DATA | | | NO DATA | | | | |
| 450 | | | | | | | | | |
| 450- | 16-088● | | | 16-165○ | | | | | |
| 500 | | | | 16-180○ | | | | | |
| 500- | 16-144○ | | | 16-158⊕ | | | | | |
| 550 | | | | | | | | | |
| 550- | 16-123○ | | | | NO DATA | | | | |
| 600 | | | | | | | | | |
| | OTHERS | 850-900 | 16-112⦶ | 600-650 | 16-179⊕ | | | | |
| | | | | 1000-1050 | 16-167○ | 16-168○ | | | |
| | | | | 1450-1500 | 16-147⊕ | | | | |
| | | | | 2250-2280 | 16-159⊕ | | | | |

Figure 38. Diurnal Vertical Distribution of _Nematoscelis difficilis_ in the Gulf of California.

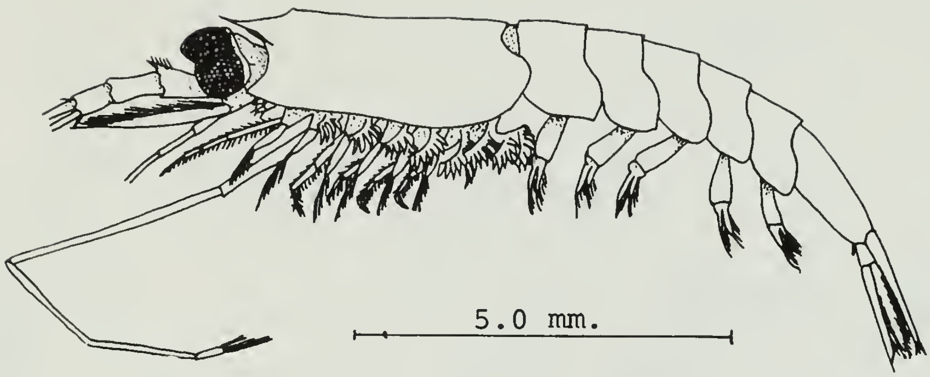



Figure 39. Nematoscelis gracilis Hansen. Adult female. (After Boden et al, (1955))

Lengths are up to 11.5 mm. for males and up to 15.5 mm. for females.

Adults are usually found below 100 meters; larvae 150 meters to the surface.

A total of 952 specimens were found in 17 trawls (see Figures 40-44).

(3) Nematoscelis tenella G. O. Sars. The rostrum is oblong-triangular and moderately short. The lateral denticle on the inferior margin of the carapace is lacking in both sexes, except for adult males from the Atlantic where it is present. The dark brown lower section of the eye is very much smaller than the upper, and they are separated by a lighter, transverse band. The elongated second thoracic leg carries seven spines on its terminal segment.

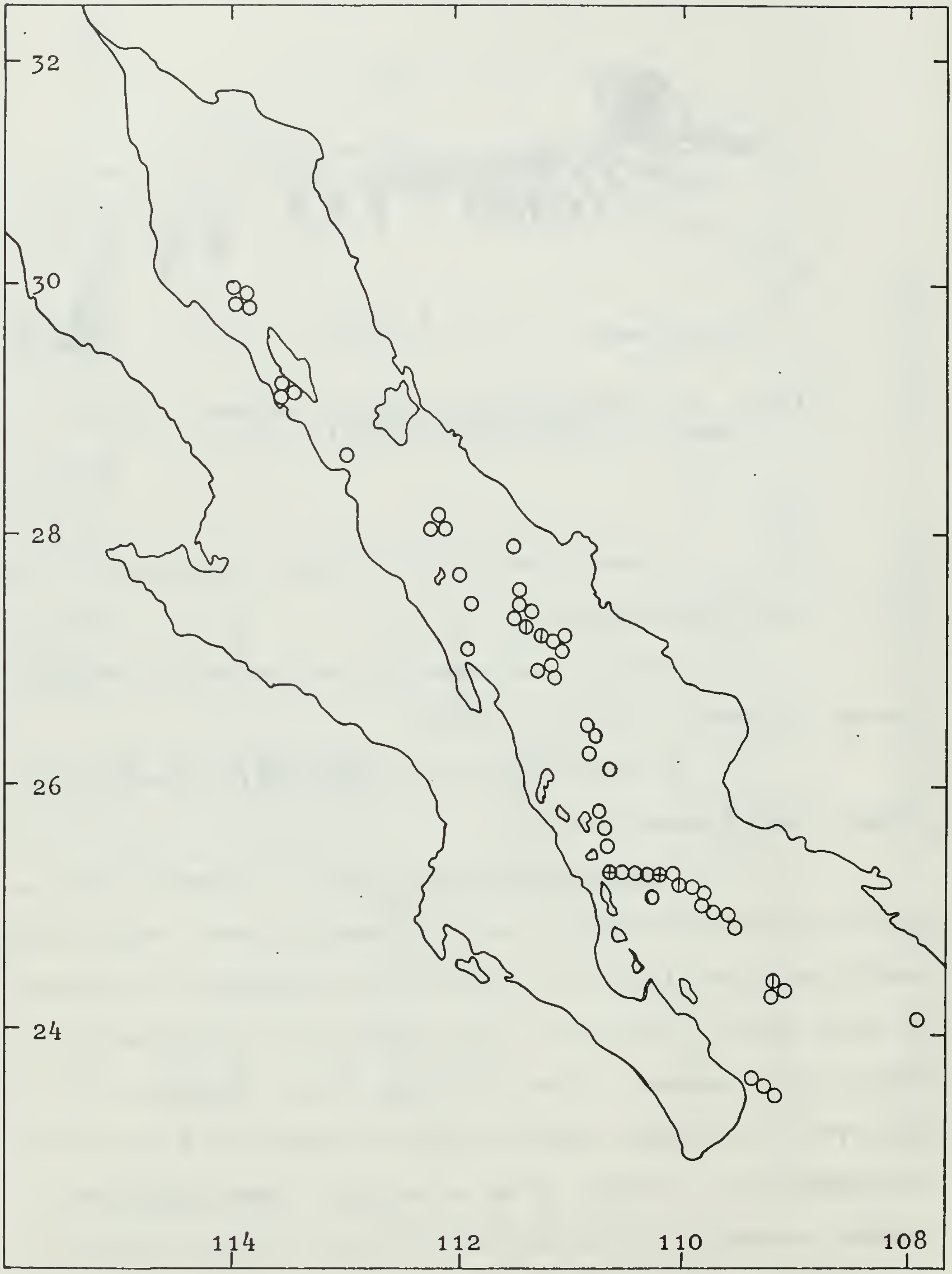



Figure 40. Horizontal Distribution of Nematoscelis gracilis in the Gulf of California

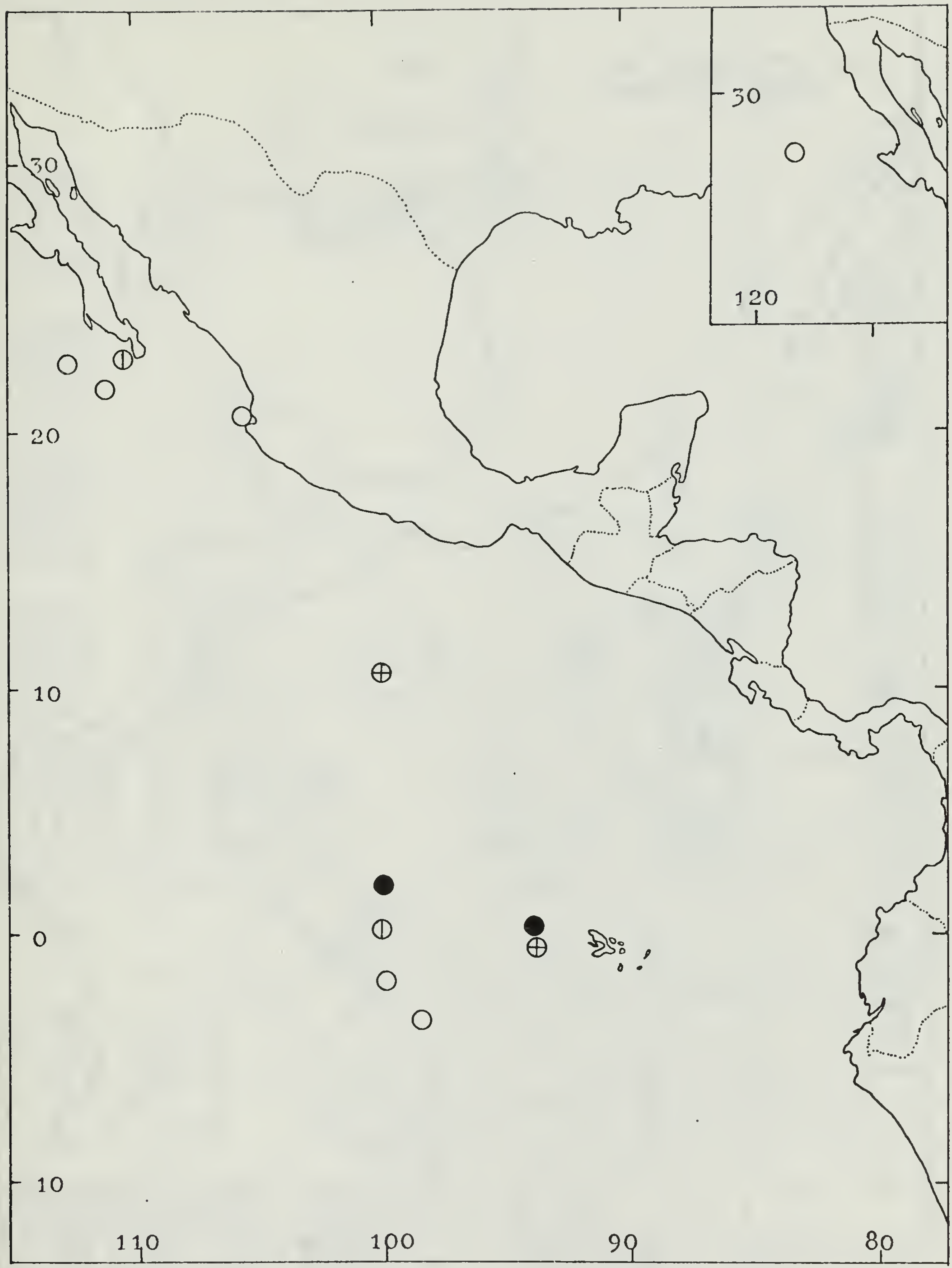



Figure 41. Horizontal Distribution of <u>Nematoscelis gracilis</u> in the Eastern Tropical Pacific

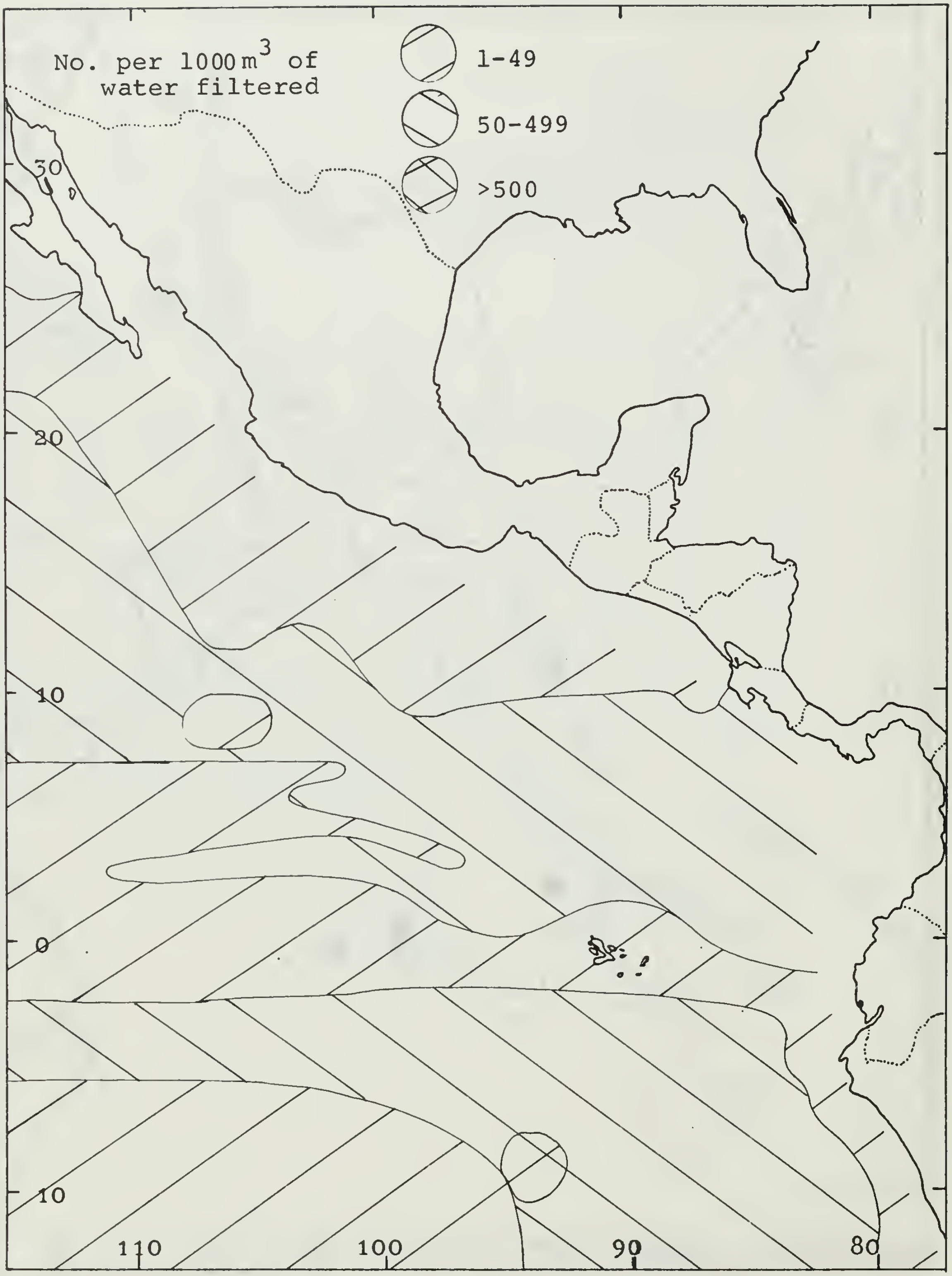



Figure 42. Horizontal Distribution of Nematoscelis gracilis in the Eastern Tropical Pacific found by Brinton. (After Brinton, (1962))

| DEPTH (m) | DAY | NIGHT |
|---|---|---|
| 0-50 | 16-012○ 16-140○ 16-094○ | 16-021○ 16-022○ 16-061○ 16-083○ 16-113○ 16-21A○ 16-056○ 16-067○ 16-102○ 16-127○ |
| 50-100 | 16-124○ 16-169○ 16-138○ | 16-033○ 16-084○ 16-095○ 16-119○ 16-131○ 16-139○ 16-039○ 16-090○ 16-114⦶ 16-126○ 16-132⦶ |
| 100-150 | 16-063○ 16-163○ | 16-156⊕ |
| 150-200 | 16-074○ 16-137○ 16-121○ | 16-148○ |
| 200-250 | 16-19A⦶ 16-122○ 16-087○ | 16-091○ 16-178○ 16-152○ |
| 250-300 | 16-161○ | 16-118○ 16-125○ |
| 300-350 | 16-062○ 16-136○ 16-135○ | 16-157○ 16-166○ |
| 350-400 | 16-035○ 16-111○ 16-160⊕ 16-064○ 16-145○ 16-162⦶ | NO DATA |
| 400-450 | NO DATA | NO DATA |
| 450-500 | 16-088○ | 16-165○ 16-180○ |
| 500-550 | 16-144○ | 16-158○ |
| 550-600 | 16-123○ | NO DATA |
| OTHERS | 850-900 16-112○ | 600-650 16-179○; 1000-1050 16-167○ 16-168○; 1450-1500 16-147○; 2250-2280 16-159○ |

Figure 43. Diurnal Vertical Distribution of *Nematoscelis gracilis* in the Gulf of California

| DEPTH (m) | DAY | | | NIGHT | | |
|---|---|---|---|---|---|---|
| 0-50 | NO DATA | | | 17-003○ | 17-026○ | 16-190○ |
| | | | | 17-020⦶ | 17-028○ | |
| 50-100 | 17-016○ | | | 17-044○ | 16-188○ | |
| | | | | 17-051○ | | |
| 100-150 | 17-050○ | | | 17-019⊕ | | |
| | | | | 17-068○ | | |
| 150-200 | 17-058○ | 17-061○ | | 17-035⦶ | | |
| | 17-060○ | | | 17-062⦶ | | |
| 200-250 | 17-010○ | 17-040○ | 16-191⦶ | 17-037○ | | |
| | 17-015○ | 17-041○ | | | | |
| 250-300 | 17-008○ | 16-193○ | | 17-007○ | | |
| | 17-070○ | | | | | |
| 300-350 | 17-047○ | 17-066○ | 17-072○ | 17-067○ | | |
| | 17-048○ | 17-069○ | | | | |
| 350-400 | 17-032● | 17-043○ | 16-184○ | 17-038○ | | |
| | 17-042○ | 17-057⊕ | | | | |
| 400-450 | 17-017⊕ | | | | NO DATA | |
| | 17-071● | | | | | |
| 450-500 | 17-049○ | | | | NO DATA | |
| 500-550 | 17-059○ | | | 17-027⊕ | | |
| 550-600 | 17-018○ | | | 17-036○ | | |
| | OTHERS | 1000-1050 | 17-031○ | 650-700 | 16-186○ | |
| | | | 16-192⦶ | 750-800 | 16-189○ | |
| | | 2000-2050 | 17-065○ | 1000-1050 | 17-029○ | 17-064○ |
| | | | | UNKNOWN DEPTH | 17-055○ | |

Figure 44. Diurnal Vertical Distribution of *Nematoscelis gracilis* in the Eastern Tropical Pacific

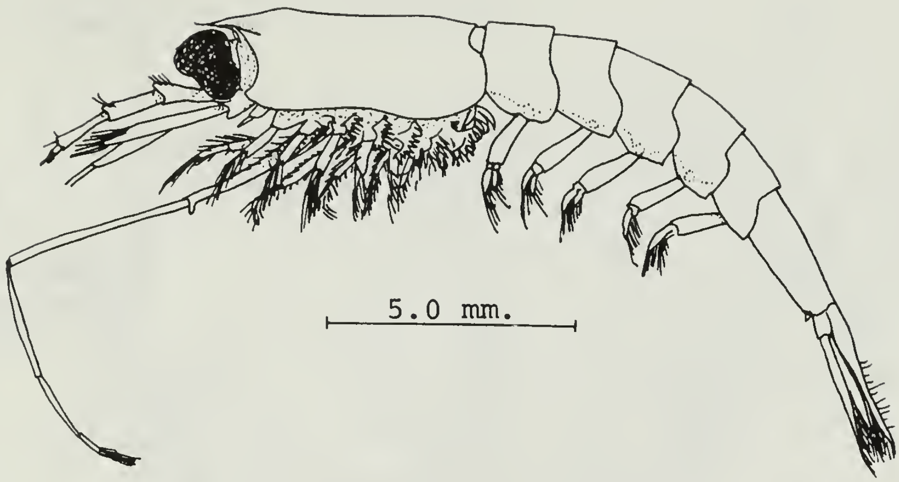



Figure 45. Nematoscelis tenella G. O. Sars. Adult female. (After Boden et al, (1955))

Length: 15-21 mm.

Adults are found below 200 meters; larvae frequently above 100 meters.

A total of 531 specimens were found in 12 trawls (see Figures 46-48).

c. The Genus Nematobrachion Calman

Generic characters: The carapace has a cervical groove and may have a lateral denticle. The large eyes are transversely constricted, with the upper section larger than the lower. The robust first antennal peduncle is similar in both sexes. The flagella are slender and long. The second antennal peduncle outer spine is about as long as the scale is broad. The mandible palp has three segments. The second thoracic leg is slightly longer than

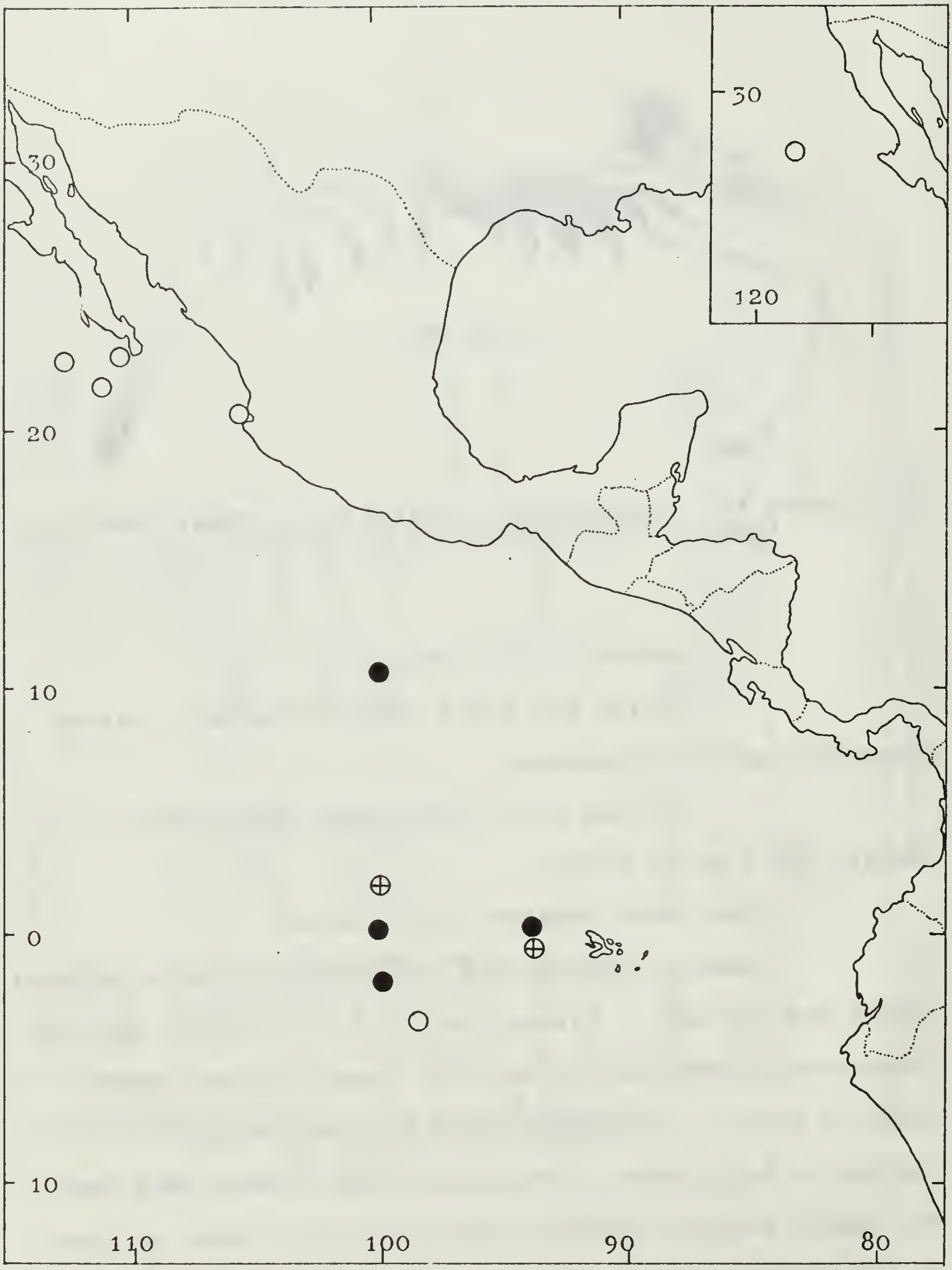



Figure 46. Horizontal Distribution of Nematoscelis tenella in the Eastern Tropical Pacific

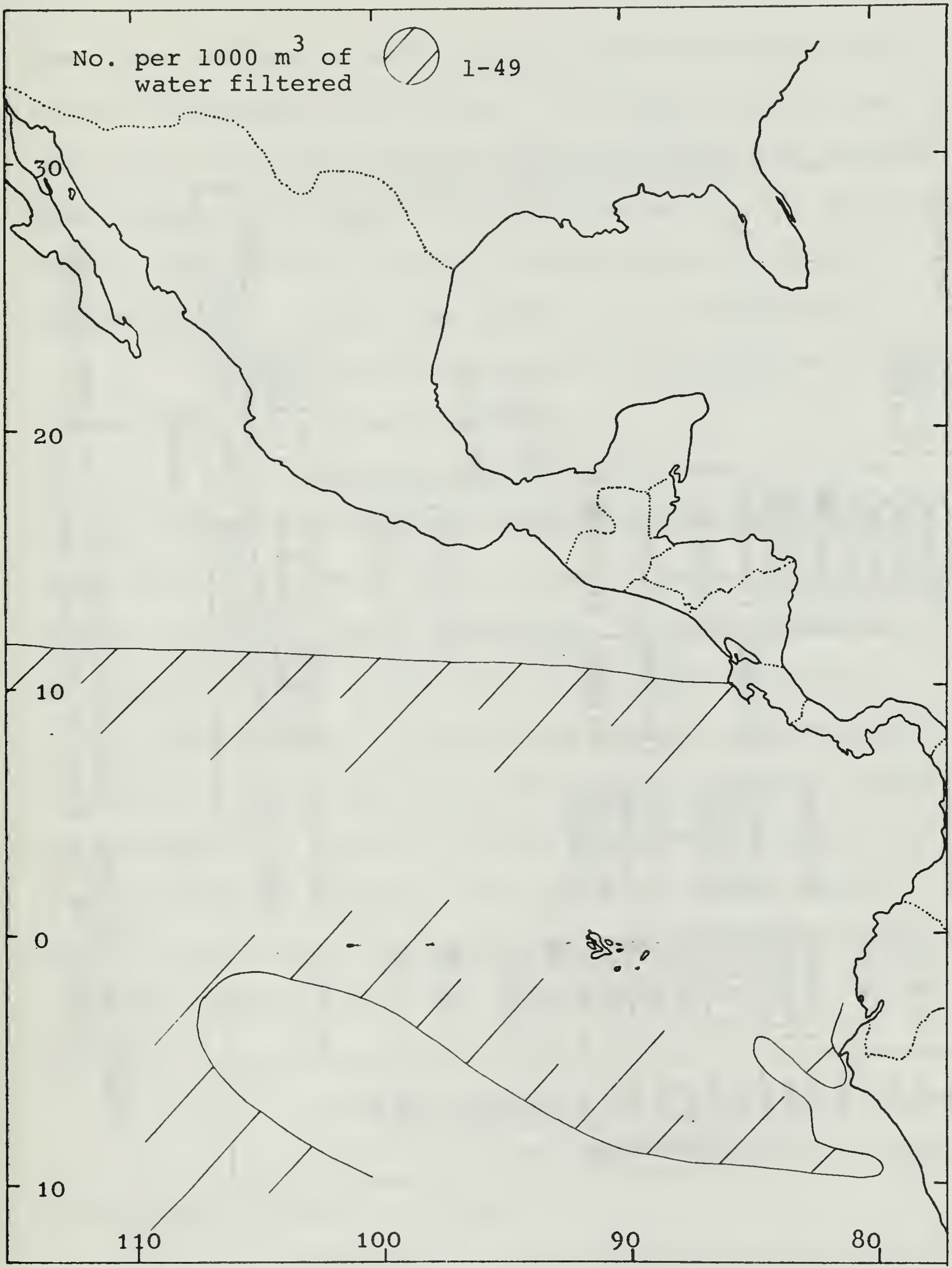



Figure 47. Horizontal Distribution of Nematoscelis tenella in the Eastern Tropical Pacific found by Brinton. (After Brinton, (1962))

| DEPTH (m) | DAY | NIGHT |
|---|---|---|
| 0-50 | NO DATA | 17-003○ 17-020○ 17-044○ 17-051○ 17-019○ 17-068● 17-035⊕ 17-062⦶ 17-037⊕ 17-026○ 17-028○ 16-188○ 16-190○ |
| 50-100 | 17-016○ | |
| 100-150 | 17-050○ | |
| 150-200 | 17-058○ 17-060○ 17-061○ | |
| 200-250 | 17-010○ 17-015○ 17-040○ 17-041○ 16-191○ | |
| 250-300 | 17-008○ 17-070○ 16-193○ | 17-007○ |
| 300-350 | 17-047○ 17-048● 17-066○ 17-069⊕ 17-072⊕ | 17-067○ |
| 350-400 | 17-032○ 17-042○ 17-043○ 17-057⦶ 16-184○ | 17-038● |
| 400-450 | 17-017● 17-071○ | NO DATA |
| 450-500 | 17-049○ | NO DATA |
| 500-550 | 17-059⊕ | 17-027○ |
| 550-600 | 17-018○ | 17-036○ |
| OTHERS | 1000-1050 17-031⊕ 16-192○<br>2000-2050 17-065○ | 650-700 16-186○<br>750-800 16-189○<br>1000-1050 17-029○ 17-064○<br>UNKNOWN DEPTH 17-055○ |

Figure 48. Diurnal Vertical Distribution of <u>Nematoscelis tenella</u> in the Eastern Tropical Pacific

the first and has a short, widened terminal segment furnished with short, stiff setae. The third thoracic leg is very long. Its merus is bent at the proximal end, and its long dactylus is armed at the tip with very long, serrated spines. The seventh thoracic leg has the full number of segments but is short. The eighth leg is rudimentary.

The genus contains three known species. The two encountered are described here.

(1) Nematobrachion boöpis Calman. The obtusely rounded frontal plate lacks a rostrum and carries a low keel. The dorsal part of the carapace has a cervical groove and lacks lateral denticles. The very large eye is divided into a small lower and larger upper part by a light colored band. It is not transversely constricted. The first antennal peduncle basal segment anterior margin is produced as a rounded lobe which projects forward high above the second segment. The distally vaulted second segment is projected over the proximal part of the third as a feebly angular lobe. The third segment carries a short low keel.

Length: 19-21 mm.

Adults are found below 400 meters; larvae occasionally above 300 meters.

A total of 12 specimens were found in one trawl (see Figures 50-52).

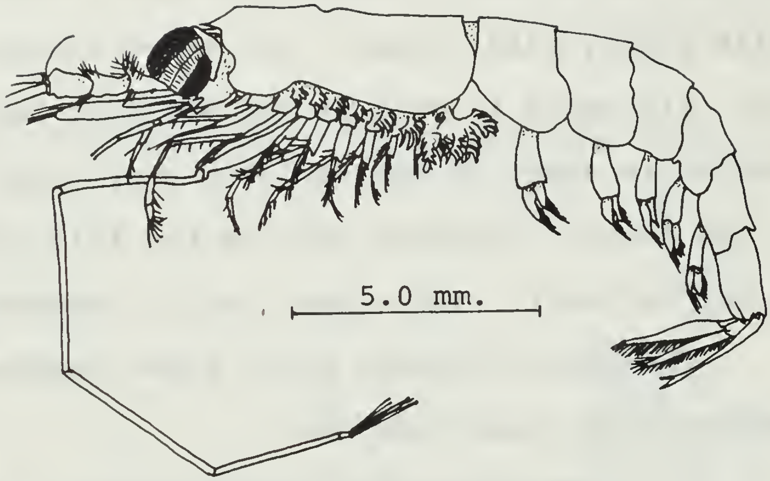



Figure 49. Nematobrachion boöpis Calman. Adult female. (After Boden et al, (1955))

(2) Nematobrachion flexipes (Ortmann) Calman. The frontal plate ends in a long, slender, spiniform, somewhat compressed rostrum. The carapace has a well-developed keel on its anterior part. A conspicuous lateral denticle is present on the inferior margin of the carapace. (Not all authorities agree on this.) The large eyes are transversely constricted, with the upper section markedly larger than the lower. The first antennal peduncle first segment has a very concave outer margin from which a long, spiniform process projects forward to beyond the middle of the second segment. The first segment dorsal tip is raised as a low, setiferous lobe. The second segment outer distal corner is produced in a process, lamellar at the base but tapering rapidly so that its distal half forms a spine directed

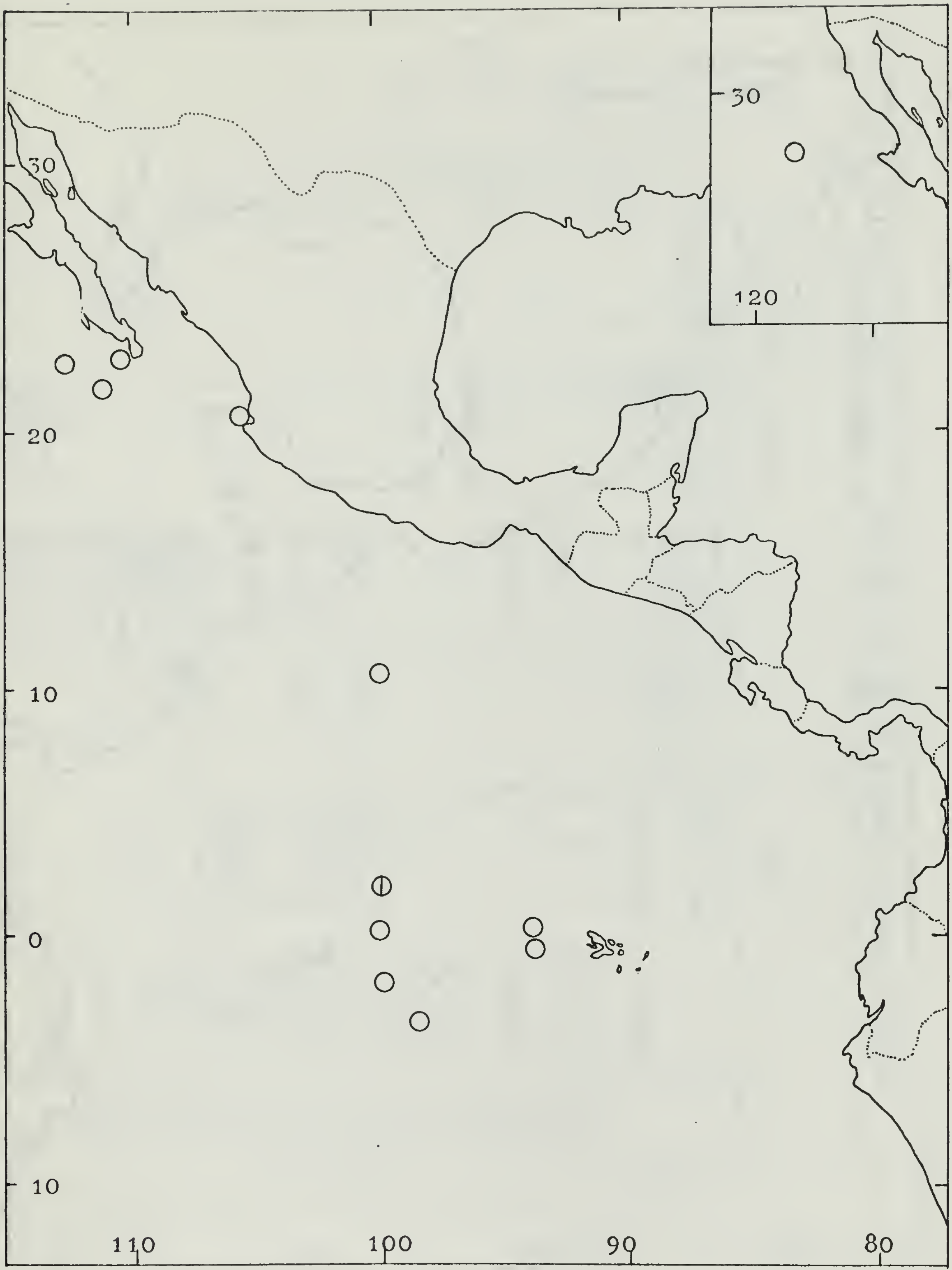



Figure 50. Horizontal Distribution of Nematobrachion boöpis in the Eastern Tropical Pacific

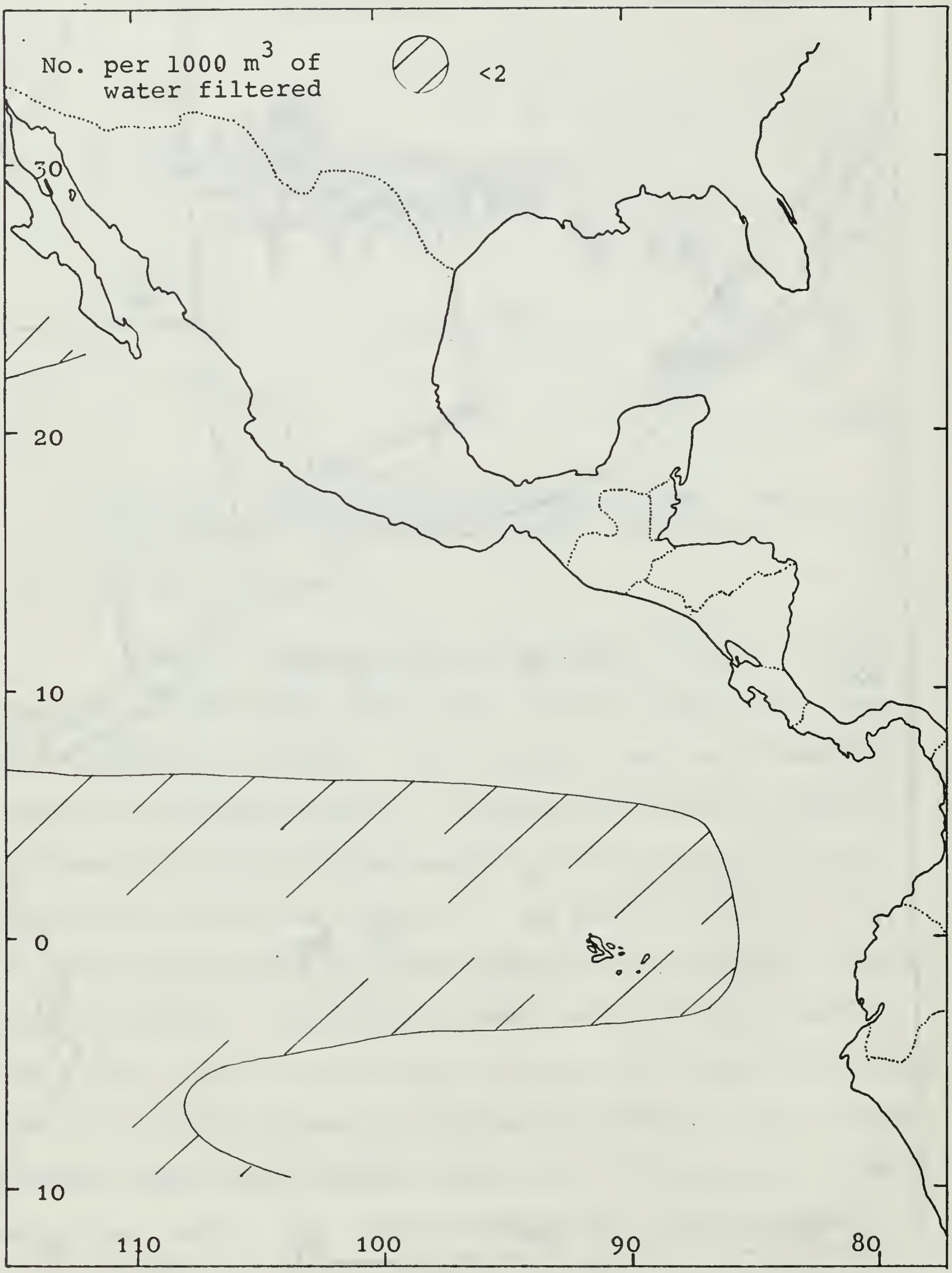



Figure 51. Horizontal Distribution of Nematobrachion boöpis in the Eastern Tropical Pacific found by Brinton. (After Brinton, (1962))

| DEPTH (m) | DAY | NIGHT |
|---|---|---|
| 0-50 | NO DATA | 17-003○ 17-026○ 16-190○<br>17-020○ 17-028○<br>17-044○ 16-188○ |
| 50-100 | 17-016○ | 17-051○ |
| 100-150 | 17-050○ | 17-019○<br>17-068○ |
| 150-200 | 17-058○ 17-061○<br>17-060○ | 17-035○<br>17-062○ |
| 200-250 | 17-010○ 17-040○ 16-191○<br>17-015○ 17-041○ | 17-037○ |
| 250-300 | 17-008○ 16-193○<br>17-070○ | 17-007○ |
| 300-350 | 17-047○ 17-066○ 17-072○<br>17-048○ 17-069○ | 17-067○ |
| 350-400 | 17-032◐ 17-043○ 16-184○<br>17-042○ 17-057○ | 17-038○ |
| 400-450 | 17-017○<br>17-071○ | NO DATA |
| 450-500 | 17-049○ | NO DATA |
| 500-550 | 17-059○ | 17-027○ |
| 550-600 | 17-018○ | 17-036○ |
| OTHERS | 1000-1050 17-031○<br>16-192○<br>2000-2050 17-065○ | 650-700 16-186○<br>750-800 16-189○<br>1000-1050 17-029○ 17-064○<br>UNKNOWN DEPTH 17-055○ |

DAY NIGHT

Figure 52. Diurnal Vertical Distribution of Nematobrachion boöpis in the Eastern Tropical Pacific

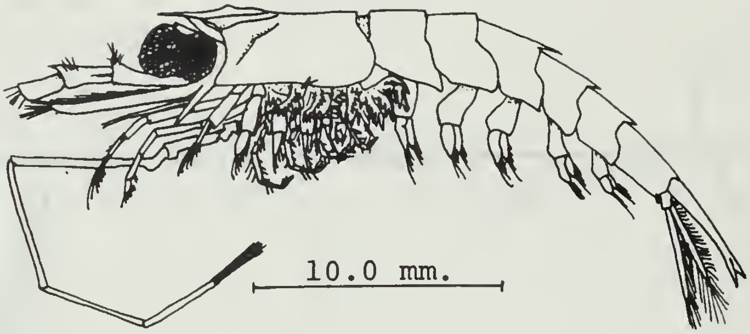



Figure 53. Nematobrachion flexipes (Ortmann) Calman. Adult female. (After Boden et al, (1955))

forward, upward, and outward. A very short, low dorsal keel is bourne on the third segment. The scale of the second antennal peduncle reaches almost to the middle of the third segment of the first antennal peduncle. The thoracic legs follow the generic description. All segments of the abdomen behind the second are armed mid-dorsally on their hind margins with conspicuous spines. The spine on the third segment is generally the longest. The pleura of the abdominal segments have rather acute posterolateral angles, and those of the fifth segment are somewhat produced. The preanal spine is bifid in the female and simple in the male. The exopod of the uropod is armed dorsally with stiff, long setae.

Length of males is up to 22 mm.; females up to 23 mm.

Adults range from 100 meters (at night) to 600 meters; larvae frequently above 200 meters.

A total of 1676 specimens were found in 35 trawls (see Figures 54-58).

d. The Genus Nyctiphanes G. O. Sars

Generic characters: This genus resembles Euphausia in general appearance. The elongate first antennal peduncle is stronger in the male than in the female. Its basal segment carries, distally and dorsally, a reflexed membranous lappet which differs in male and female. The third segment of the peduncle is of odd shape in the male.

There is no lateral denticle on the inferior margin of the carapace in either the adult or adolescent.

The first six thoracic appendages are as in the genus Euphausia. The seventh thoracic leg lacks terminal segments. The quite rudimentary eighth thoracic appendage consists of a minute, digitiform, nonsetose process. The exopodites of the sixth and seventh thoracic appendages of the female are lacking.

There are four known species in the genus. The one encountered is described here.

(1) Nyctiphanes simplex Hansen. The fairly long and acute frontal plate of the carapace has the lateral margins raised. There is no distinct rostrum. There is a distinct cervical groove and median keel. The gastric region of the carapace is vaulted. The black eyes are moderately large and spherical. The outer corner of the distal end of the basal segment of the first antennal

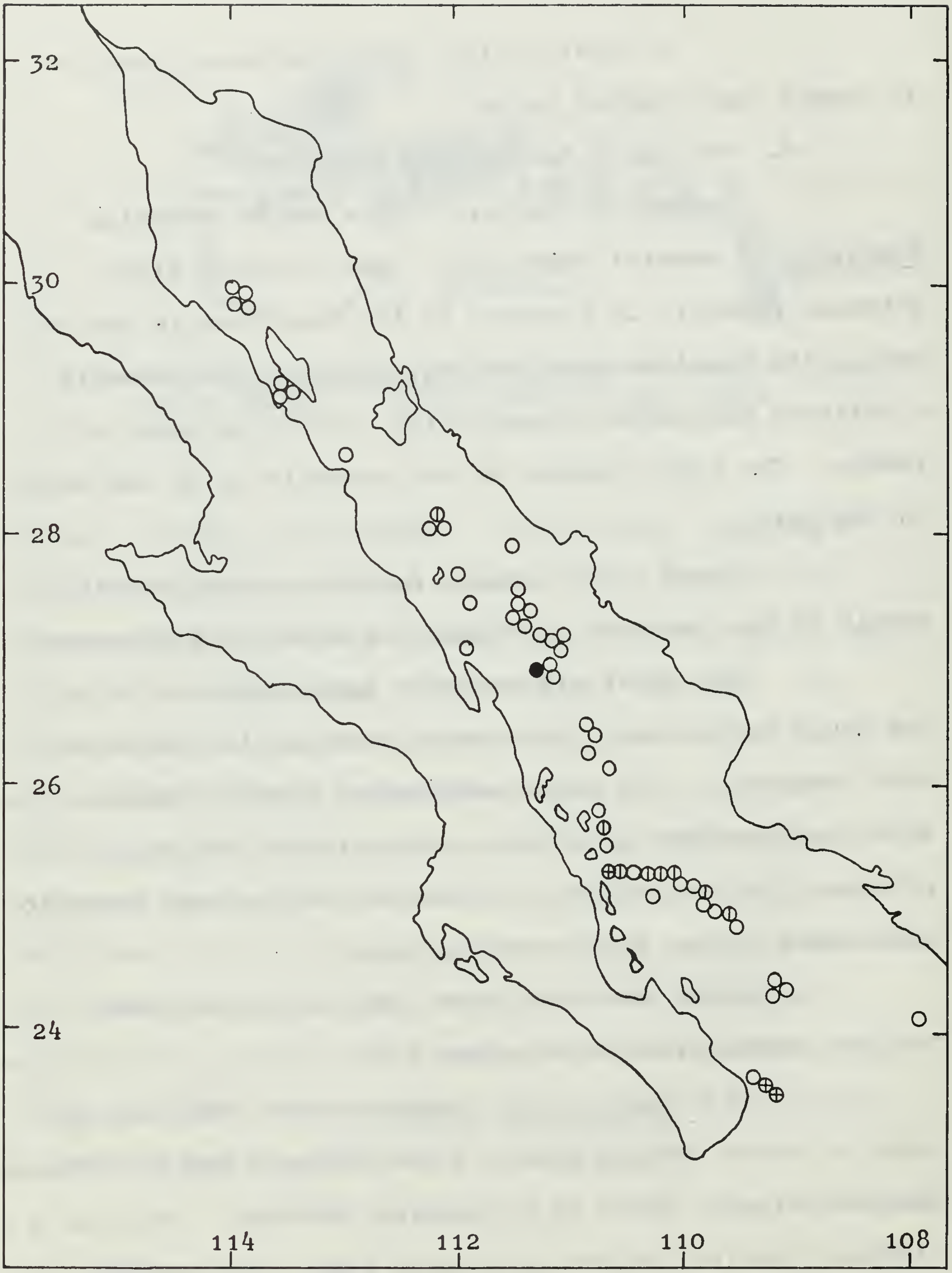



Figure 54. Horizontal Distribution of Nematobrachion flexipes in the Gulf of California

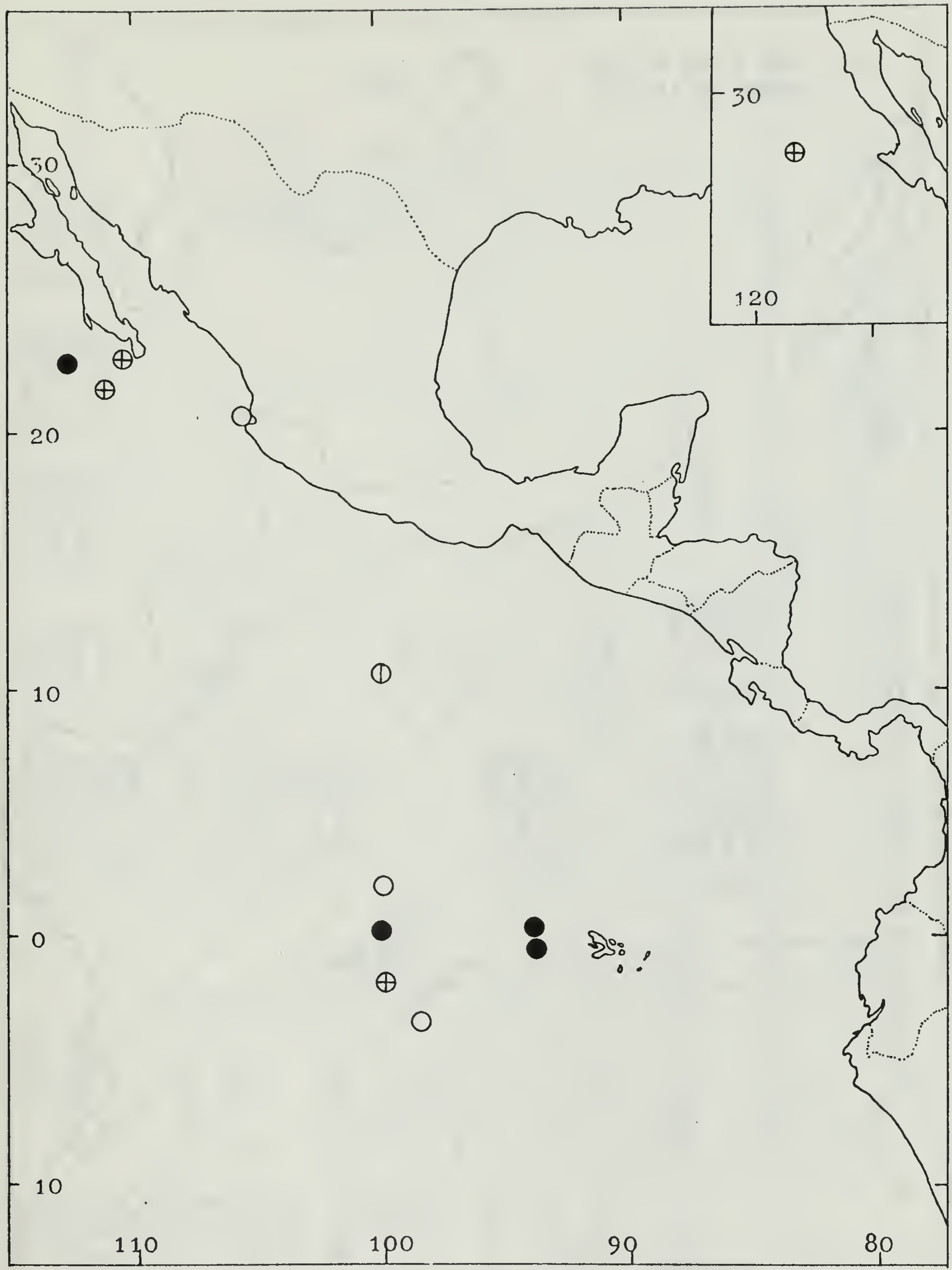



Figure 55. Horizontal Distribution of Nematobrachion flexipes in the Eastern Tropical Pacific

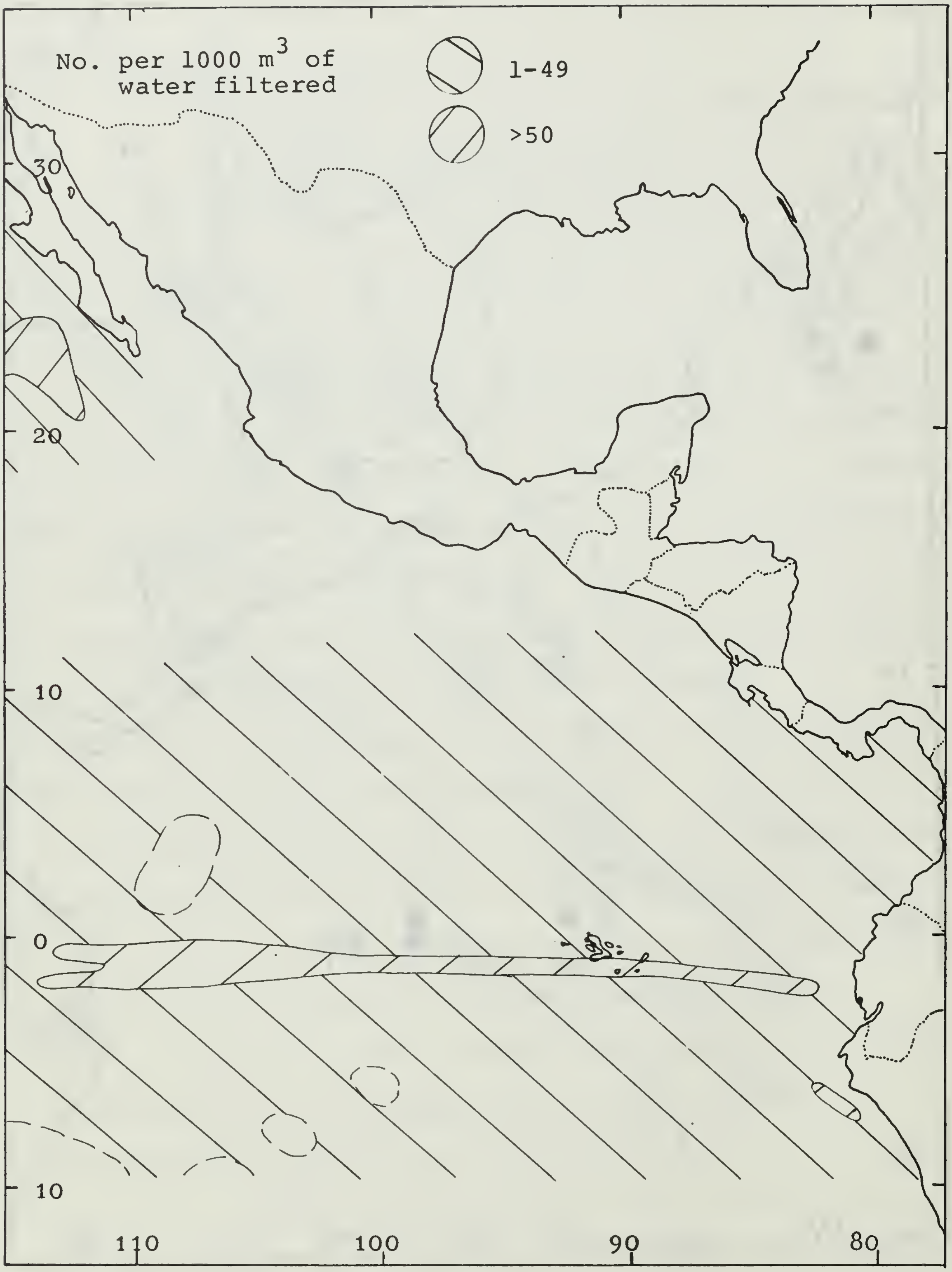



Figure 56. Horizontal Distribution of Nematobrachion flexipes in the Eastern Tropical Pacific found by Brinton. (After Brinton, (1962))

| DEPTH (m) | DAY | NIGHT |
| --- | --- | --- |
| 0-50 | 16-012○ 16-140○<br>16-094○ | 16-021○ 16-022○ 16-061○ 16-083○ 16-113○<br>16-21A○ 16-056○ 16-067○ 16-102○ 16-127○ |
| 50-100 | 16-124○ 16-169○<br>16-138○ | 16-033○ 16-084○ 16-095○ 16-119○ 16-131○ 16-139○<br>16-039○ 16-090○ 16-114○ 16-126○ 16-132○ |
| 100-150 | 16-063○<br>16-163○ | 16-156⊕ |
| 150-200 | 16-074○ 16-137○<br>16-121● | 16-148○ |
| 200-250 | 16-19A○ 16-122○<br>16-087○ | 16-091○ 16-178○<br>16-152○ |
| 250-300 | 16-161⦶ | 16-118○<br>16-125○ |
| 300-350 | 16-062○ 16-136○<br>16-135○ | 16-157⦶<br>16-166○ |
| 350-400 | 16-035⦶ 16-111○ 16-160⦶<br>16-064⦶ 16-145○ 16-162○ | NO DATA |
| 400-450 | NO DATA | NO DATA |
| 450-500 | 16-088○ | 16-165⦶<br>16-180⊕ |
| 500-550 | 16-144○ | 16-158○ |
| 550-600 | 16-123○ | NO DATA |
| OTHERS | 850-900 16-112○ | 600-650 16-179⊕<br>1000-1050 16-167○ 16-168⊕<br>1450-1500 16-147○<br>2250-2280 16-159⦶ |

Figure 57. Diurnal Vertical Distribution of Nematobrachion flexipes in the Gulf of California

| DEPTH (m) | DAY | NIGHT |
|---|---|---|
| 0-50 | NO DATA | 17-003⊕ 17-020○ 17-044⊕ 17-051⊕ 17-019⦶ 17-068○ 17-026○ 17-028○ 16-188⦶ 16-190○ |
| 50-100 | 17-016○ | |
| 100-150 | 17-050○ | |
| 150-200 | 17-058○ 17-060○ 17-061○ | 17-035● 17-062⦶ |
| 200-250 | 17-010○ 17-015○ 17-040○ 17-041○ 16-191⊕ | 17-037● |
| 250-300 | 17-008⊕ 17-070○ 16-193⦶ | 17-007● |
| 300-350 | 17-047○ 17-048⦶ 17-066⊕ 17-069⦶ 17-072⦶ | 17-067● |
| 350-400 | 17-032○ 17-042○ 17-043⊕ 17-057⦶ 16-184○ | 17-038○ |
| 400-450 | 17-017○ 17-071⦶ | NO DATA |
| 450-500 | 17-049○ | NO DATA |
| 500-550 | 17-059○ | 17-027○ |
| 550-600 | 17-018○ | 17-036○ |
| OTHERS | 1000-1050 17-031○ 16-192⦶; 2000-2050 17-065○ | 650-700 16-186○; 750-800 16-189⊕; 1000-1050 17-029○ 17-064●; UNKNOWN DEPTH 17-055○ |

Figure 58. Diurnal Vertical Distribution of Nematobrachion flexipes in the Eastern Tropical Pacific

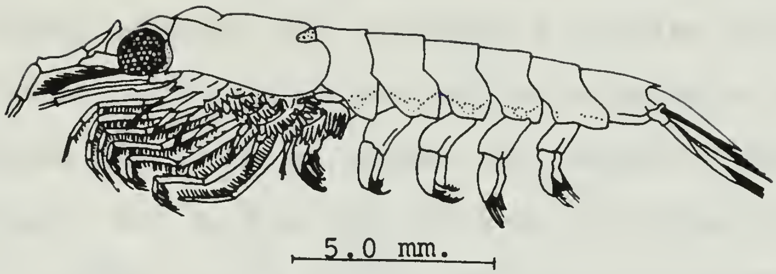



Figure 59. Nyctiphanes simplex Hansen. Adult male. (After Boden et al, (1955))

peduncle is conspicuously produced in a subconical spine, which is directed forward and outward, has a thick base, and tapers to an acute point. The forward margin dorsal surface of this segment carries a very large lappet, which is directed upward and backward, is about twice as long as broad at the base, and has a hollow anterior surface. In the female the upper end of this lappet is rounded, with a small point on the inner side. It is broadly truncate and much reflexed, and bears a sharp tooth on the outer margin in the male. In the female the long and slender second segment of the peduncle carries a small, subacute tooth on its dorsal, distal, inner angle. It is somewhat shorter and thicker, and the tooth is broader and more vertical, sometimes even bifid in the male. The third segment of the peduncle is very much shorter than the second in both sexes and has an inconspicuous keel which ends as a small tooth in the female. The male has no such tooth, and the segment is very strongly curved inward. The outer margin is complex. The concave inner margin carries a group of strong setae near the middle. In adolescent stages, the lappet on the first peduncular se ment tapers to an acute tip and is not truncated. Its outer margin is concave and its inner convex. The distal end of this segment bears an outer protuberance that is very much more pronounced than in the adult. The second antennal scales do not reach to the end of the second segment of the first antennal peduncles. The sixth abdominal segment bears a dorsal tooth at the end.

Length: 11-16 mm.

Adults and larvae are found above 200 meters.

A total of 121 specimens were found in 15 trawls (see Figures 60-63).

e. The Genus Stylocheiron G. O. Sars

Generic characters: The generally small body is variable in form. The eyes are irregularly shaped and are usually divided. The carapace lacks denticles on the lateral margin. The slender second and particularly the third peduncular segments of the first antennae of the female are long. These segments, particularly the third, are shorter and much thicker in the male. The lower flagellum is longer than the upper. In the male the segments are flattened and expanded; in the female they are slender and cylindrical. The peduncle of the second antennal endopod, particularly the penultimate segment, is

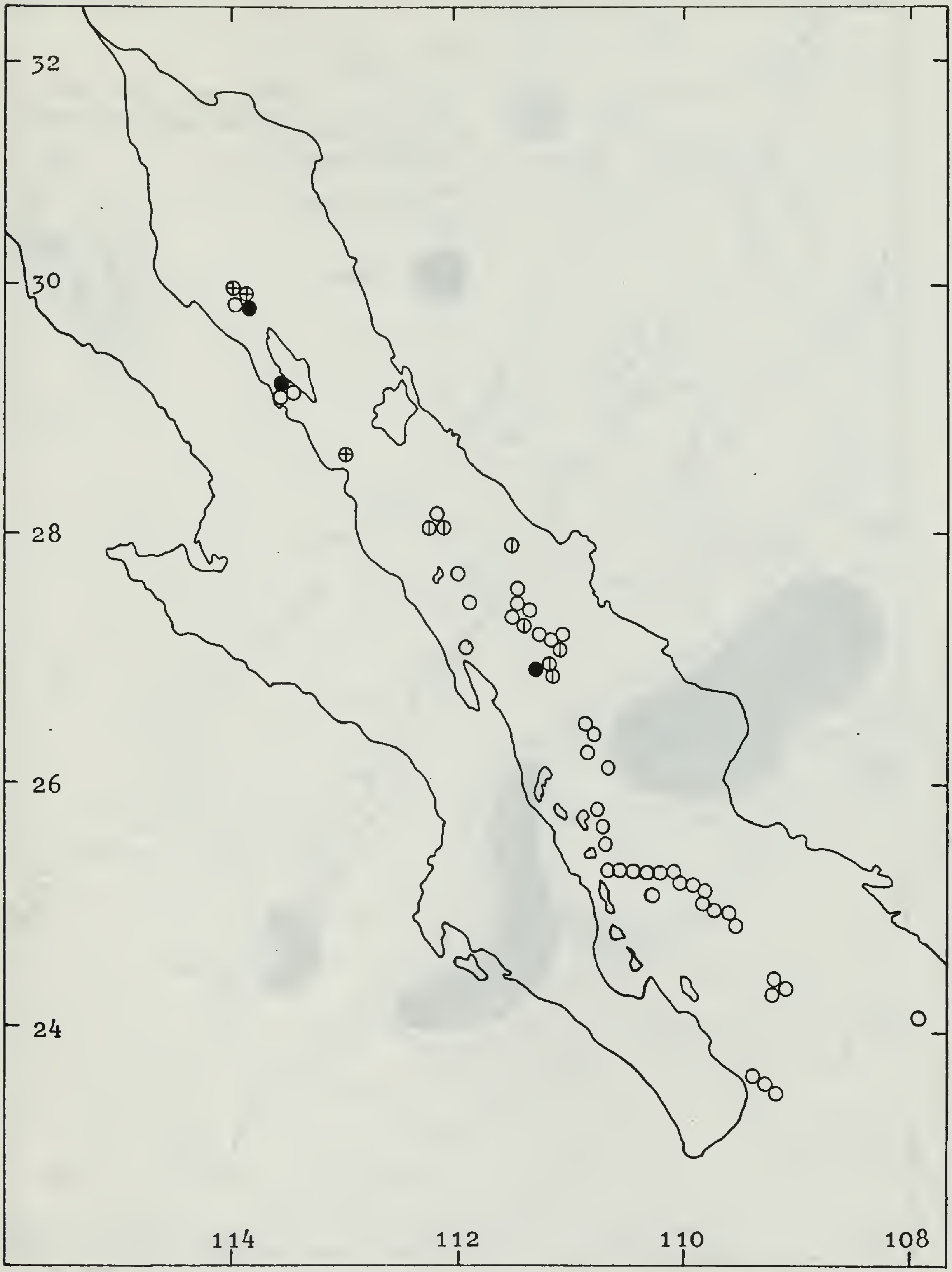



Figure 60. Horizontal Distribution of Nyctiphanes simplex in the Gulf of California.

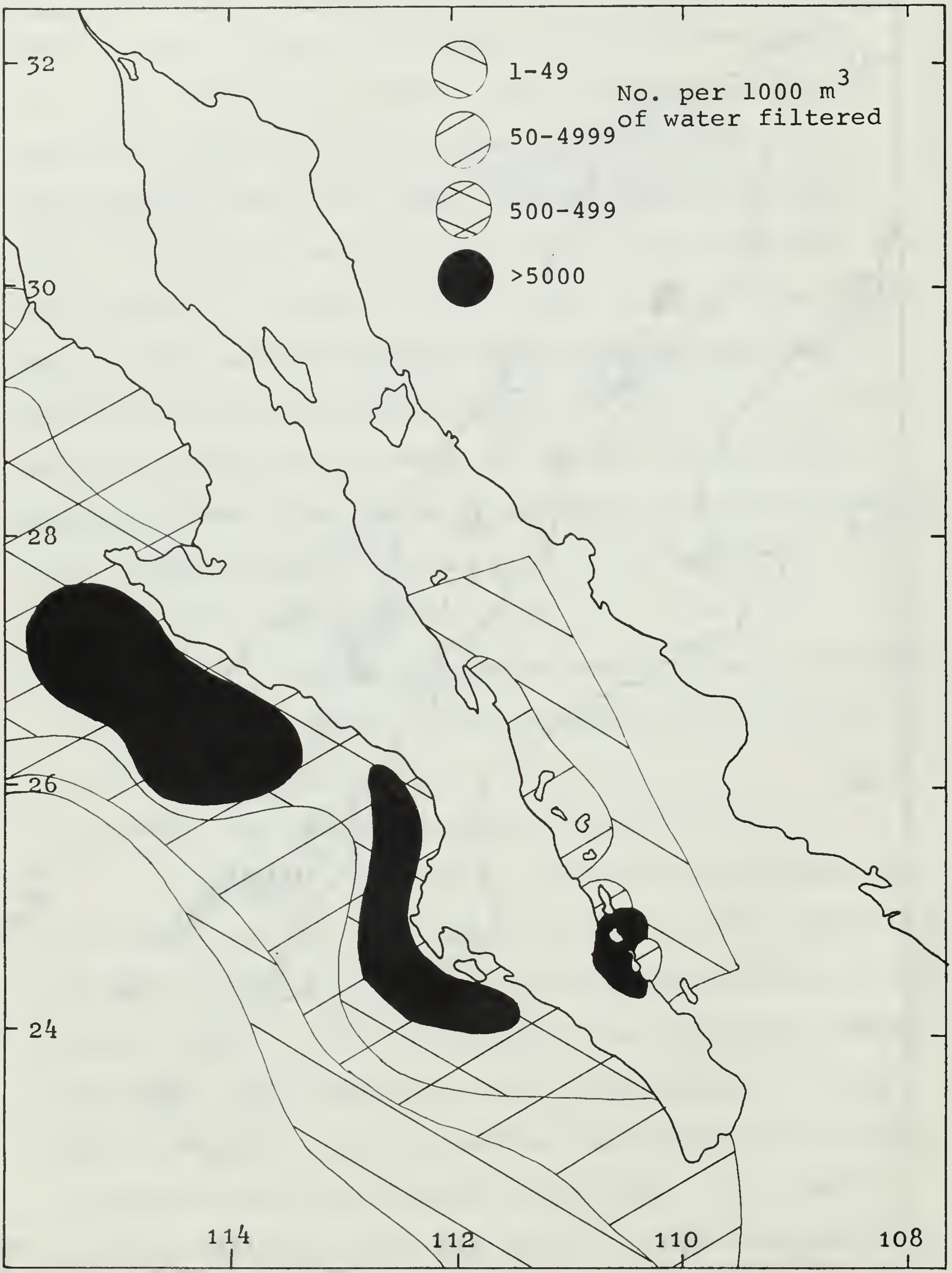



Figure 61. Horizontal Distribution of Nyctiphanes simplex in the Gulf of California found by Brinton. (After Brinton, (1962))

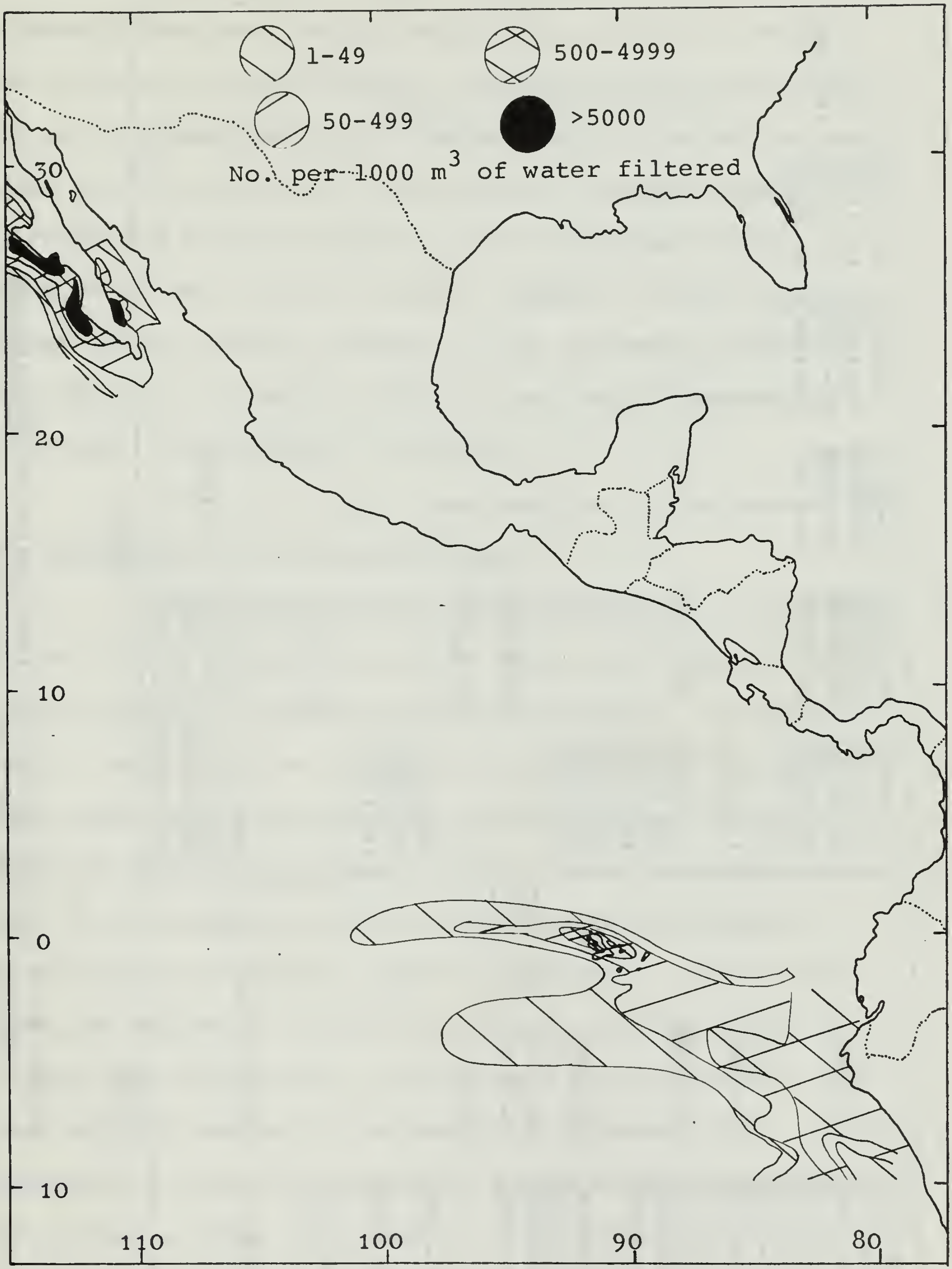



Figure 62. Horizontal Distribution of Nyctiphanes simplex in the Eastern Tropical Pacific found by Brinton. (After Brinton, (1962))

| DEPTH (m) | DAY | NIGHT |
| --- | --- | --- |
| 0-50 | 16-012○ 16-140○<br>16-094○ | 16-021○ 16-022○ 16-061○ 16-083⊕ 16-113⦶<br>16-21A○ 16-056○ 16-067⦶ 16-102⦶ 16-127⦶ |
| 50-100 | 16-124○ 16-169○<br>16-138○ | 16-033○ 16-084● 16-095● 16-119⦶ 16-131○ 16-139○<br>16-039○ 16-090⊕ 16-114○ 16-126○ 16-132⦶ |
| 100-150 | 16-063⦶<br>16-163○ | 16-156○ |
| 150-200 | 16-074⊕ 16-137○<br>16-121○ | 16-148○ |
| 200-250 | 16-19A○ 16-122●<br>16-087○ | 16-091⊕ 16-178○<br>16-152○ |
| 250-300 | 16-161○ | 16-118⦶<br>16-125○ |
| 300-350 | 16-062○ 16-136○<br>16-135○ | 16-157○<br>16-166○ |
| 350-400 | 16-035○ 16-111○ 16-160○<br>16-064○ 16-145○ 16-162○ | NO DATA |
| 400-450 | NO DATA | NO DATA . |
| 450-500 | 16-088○ | 16-165○<br>16-180○ |
| 500-550 | 16-144○ | 16-158○ |
| 550-600 | 16-123○ | NO DATA |
| | OTHERS 850-900 16-112○ | 600-650 16-179○<br>1000-1050 16-167○ 16-168○<br>1450-1500 16-147○<br>2250-2280 16-159○ |

Figure 63. Diurnal Vertical Distribution of *Nyctiphanes simplex* in the Gulf of California

extremely long and reaches beyond the end of the scale. The first and second thoracic legs are not well-developed. The greatly produced third thoracic leg is geniculate and bears short ischial and long meral and carpal segments. A prehensile hand is formed by the strong spiniform bristles of the swollen propodal segment and the curved spines of the terminal segment. The following thoracic legs diminish in length, the last one being rudimentary. Only three light organs are present.

There are nine known species in the genus. The two encountered are described here.

(1) Stylocheiron abbreviatum G. O. Sars. The frontal plate is produced into a long, acute rostrum which reaches slightly beyond the end of the eyes. The raised gastric region of the carapace bears a short keel. The upper part of the pyriform eye bears numerous slightly enlarged crystalline cones. In the female the third segment of the peduncle of the first antenna is slightly longer than the second. Both are slender. In the male these two segments are much thickened, and the third is shorter than the second. In the male the flagella of the first antenna are much shortened and thickened. The upper flagellum is expanded proximally and flattened distally and is shorter than the peduncle. The upper flagellum is two-thirds as long as the lower, which is much constricted between its second and fifth segments. A true chela is borne on the long third thoracic leg. The adult fourth and fifth abdominal segments sometimes bear low mid-dorsal keels.

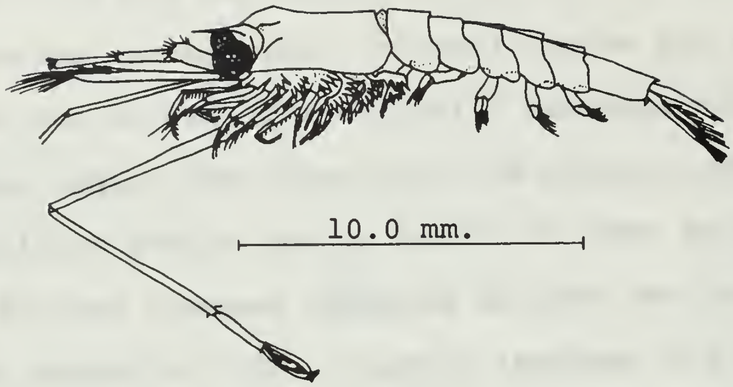



Figure 64. Stylocheiron abbreviatum G. O. Sars. Adult female. (After Boden et al, (1955))

Male length is 15 mm.; female 16 mm.

Adults and larvae are found between 100 and 400 meters.

A total of 145 specimens were found in six trawls (see Figures 65-67).

(2) Stylocheiron maximum Hansen. The frontal plate is produced into a long, sharp rostrum which reaches to the end of the eyes. The somewhat vaulted or domed gastric region of the carapace bears a keel anteriorly. The thoracic region is very robust. The gills are extremely arborescent. The long third thoracic leg bears a true chela. The eye is large, elongated, and constricted medially. The more anterior upper part is about four-fifths the width of the lower part. No enlarged crystalline cones are present, although the facets of the upper part of the eye are slightly larger than those of the lower.

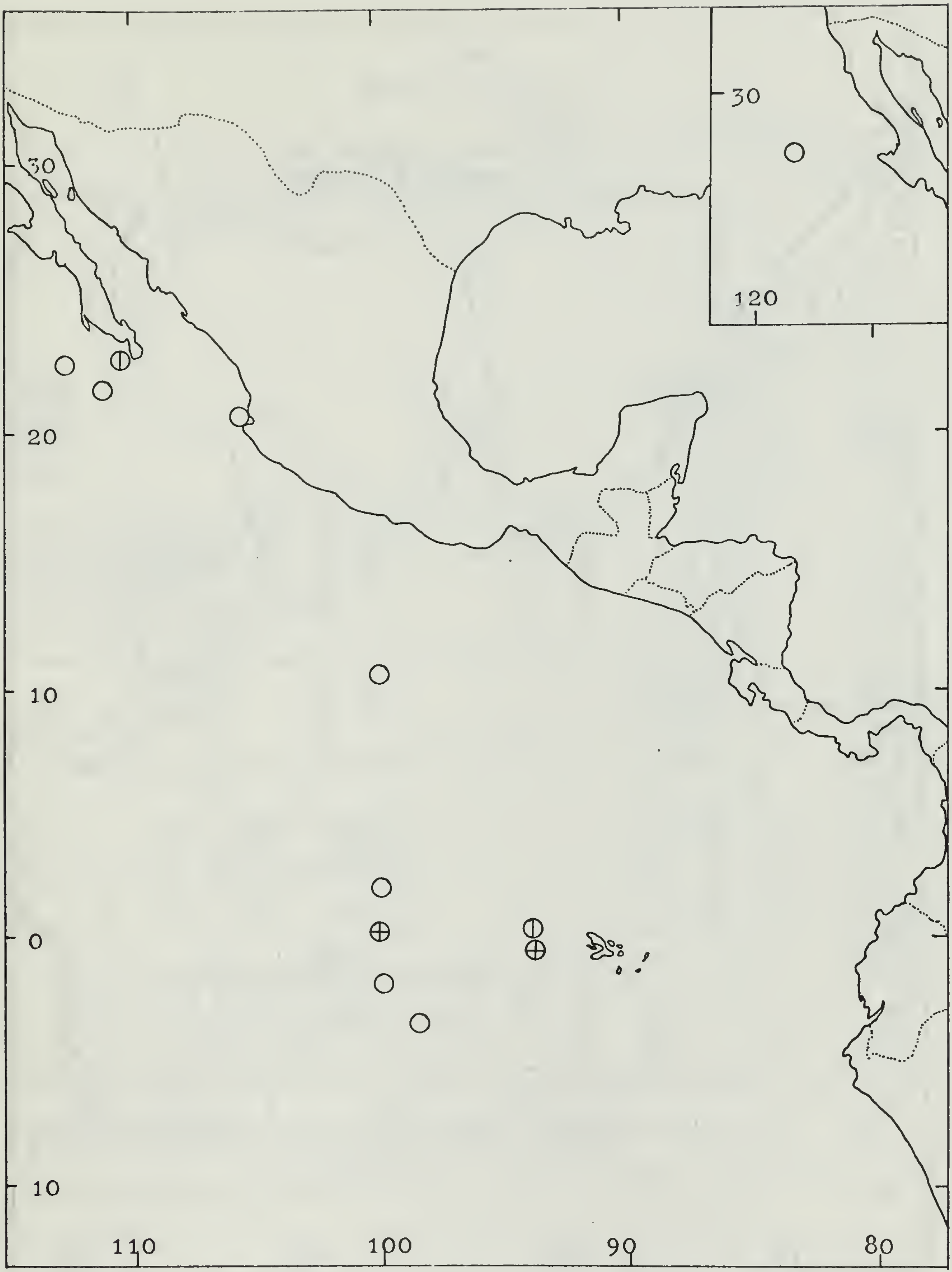



Figure 65. Horizontal Distribution of <u>Stylocheiron abbreviatum</u> in the Eastern Tropical Pacific

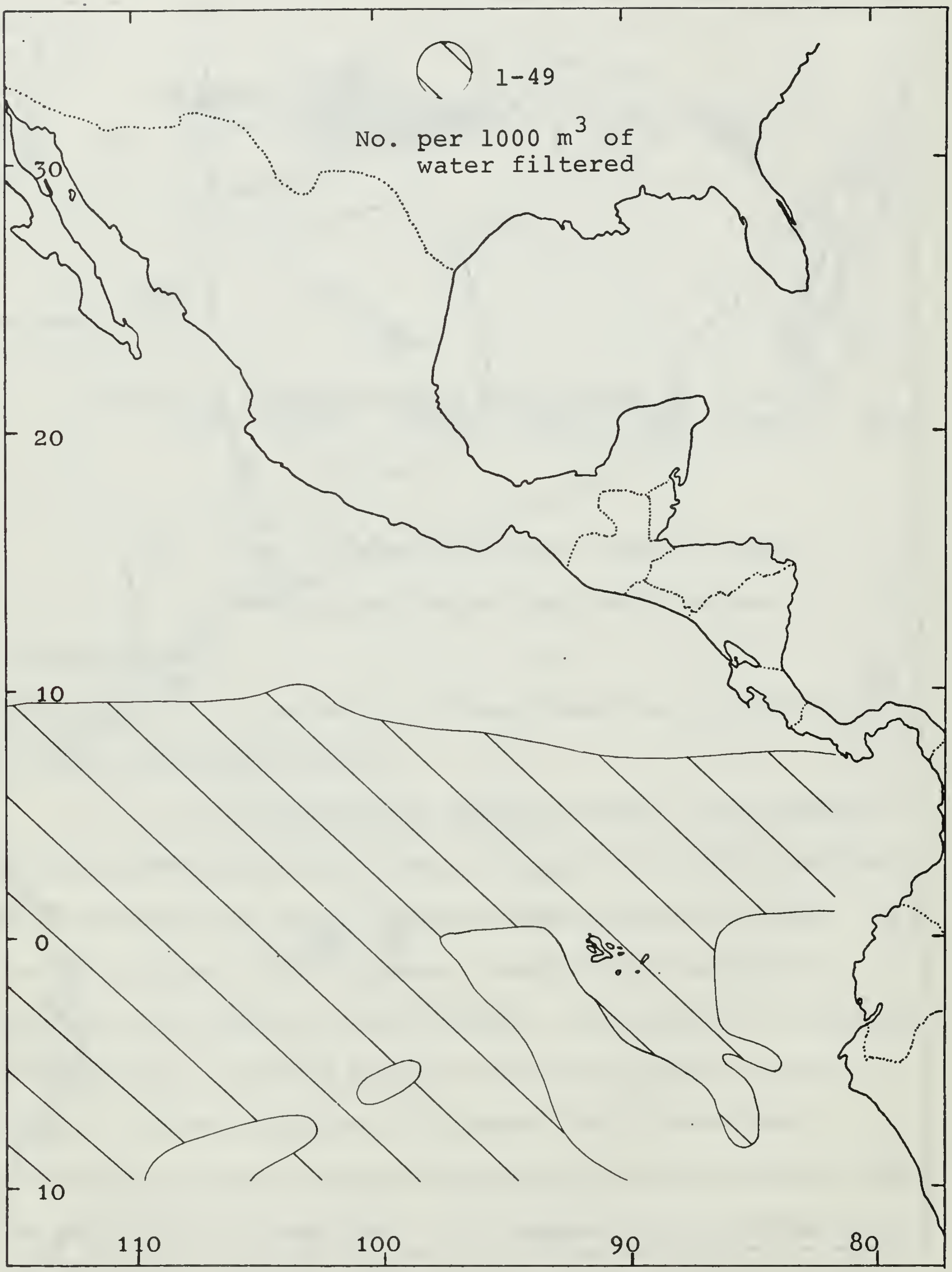



Figure 66. Horizontal Distribution of Stylocheiron abbreviatum in the Eastern Tropical Pacific found by Brinton. (After Brinton, (1962))

| DEPTH (m) | DAY | | | NIGHT | | |
|---|---|---|---|---|---|---|
| 0- | | NO DATA | | 17-003○ | 17-026○ | 16-190○ |
| 50 | | | | 17-020○ | 17-028○ | |
| 50- | 17-016○ | | | 17-044○ | 16-188○ | |
| 100 | | | | 17-051○ | | |
| 100- | 17-050○ | | | 17-019○ | | |
| 150 | | | | 17-068○ | | |
| 150- | 17-058○ | 17-061○ | | 17-035⦶ | | |
| 200 | 17-060○ | | | 17-062⊕ | | |
| 200- | 17-010○ | 17-040○ | 16-191○ | 17-037⦶ | | |
| 250 | 17-015○ | 17-041○ | | | | |
| 250- | 17-008○ | 16-193○ | | 17-007○ | | |
| 300 | 17-070○ | | | | | |
| 300- | 17-047○ | 17-066○ | 17-072○ | 17-067○ | | |
| 350 | 17-048○ | 17-069⦶ | | | | |
| 350- | 17-032○ | 17-043○ | 16-184○ | 17-038⊕ | | |
| 400 | 17-042○ | 17-057○ | | | | |
| 400- | 17-017○ | | | | NO DATA | |
| 450 | 17-071○ | | | | | |
| 450- | 17-049○ | | | | NO DATA | |
| 500 | | | | | | |
| 500- | 17-059○ | | | 17-027○ | | |
| 550 | | | | | | |
| 550- | 17-018○ | | | 17-036○ | | |
| 600 | | | | | | |
| | OTHERS | 1000-1050 | 17-031○ | 650-700 | 16-186○ | |
| | | | 16-192⦶ | 750-800 | 16-189○ | |
| | | 2000-2050 | 17-065○ | 1000-1050 | 17-029○ | 17-064○ |
| | | | | UNKNOWN DEPTH | 17-055○ | |

Figure 67. Diurnal Vertical Distribution of Stylocheiron abbreviatum in the Eastern Tropical Pacific

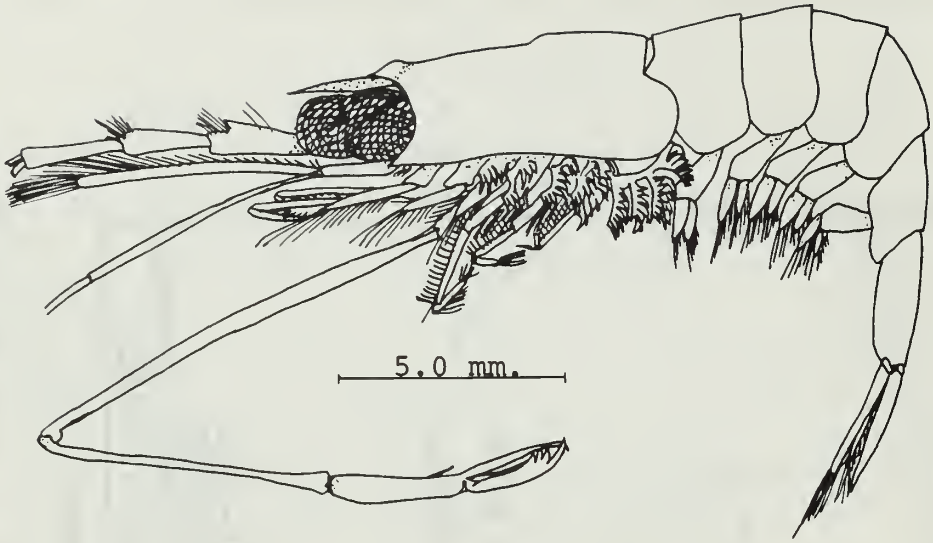



Figure 68. Stylocheiron maximum Hansen. Adult female. (After Boden et al, (1955))

Length for males: 20-25 mm.; females: 25-30 mm.

Adults are found below 400 meters; larvae below 150 meters.

A total of 43 specimens were found in five trawls (see Figures 69-71).

f. The Genus Thysanopoda Milne-Edwards

Generic characters: The shape of the rostrum is variable. The carapace may have a cervical groove. The eyes are not constricted in the adults and are sometimes reduced in size. The first and second antennal flagella are very long. The maxilla exopod is very small. The first seven thoracic legs are uniform except that the terminal segments of the first two are somewhat shorter and more setose than those of the following appendages and the seventh thoracic leg is considerably shorter than the

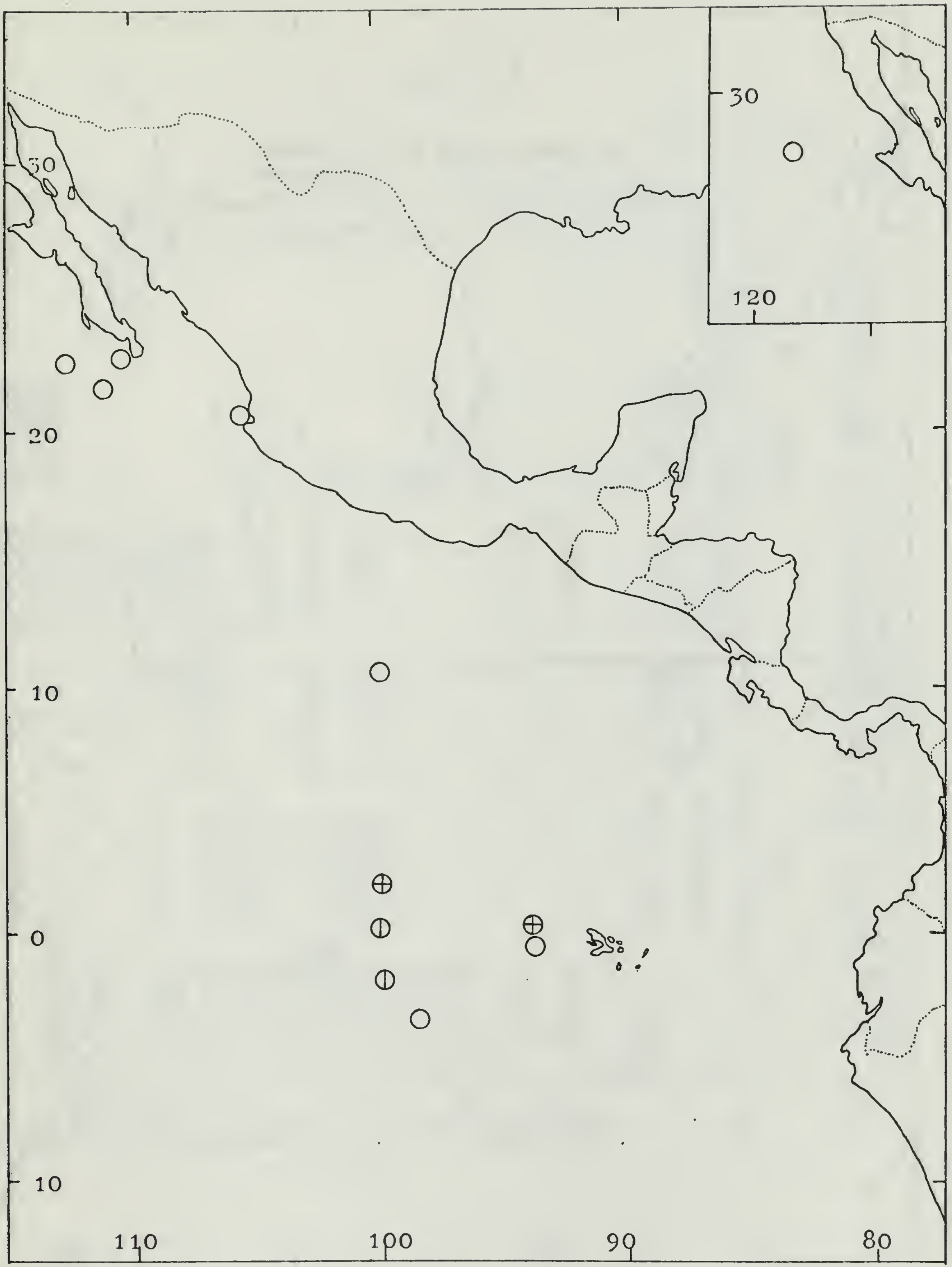



Figure 69. Horizontal Distribution of Stylocheiron maximum in the Eastern Tropical Pacific

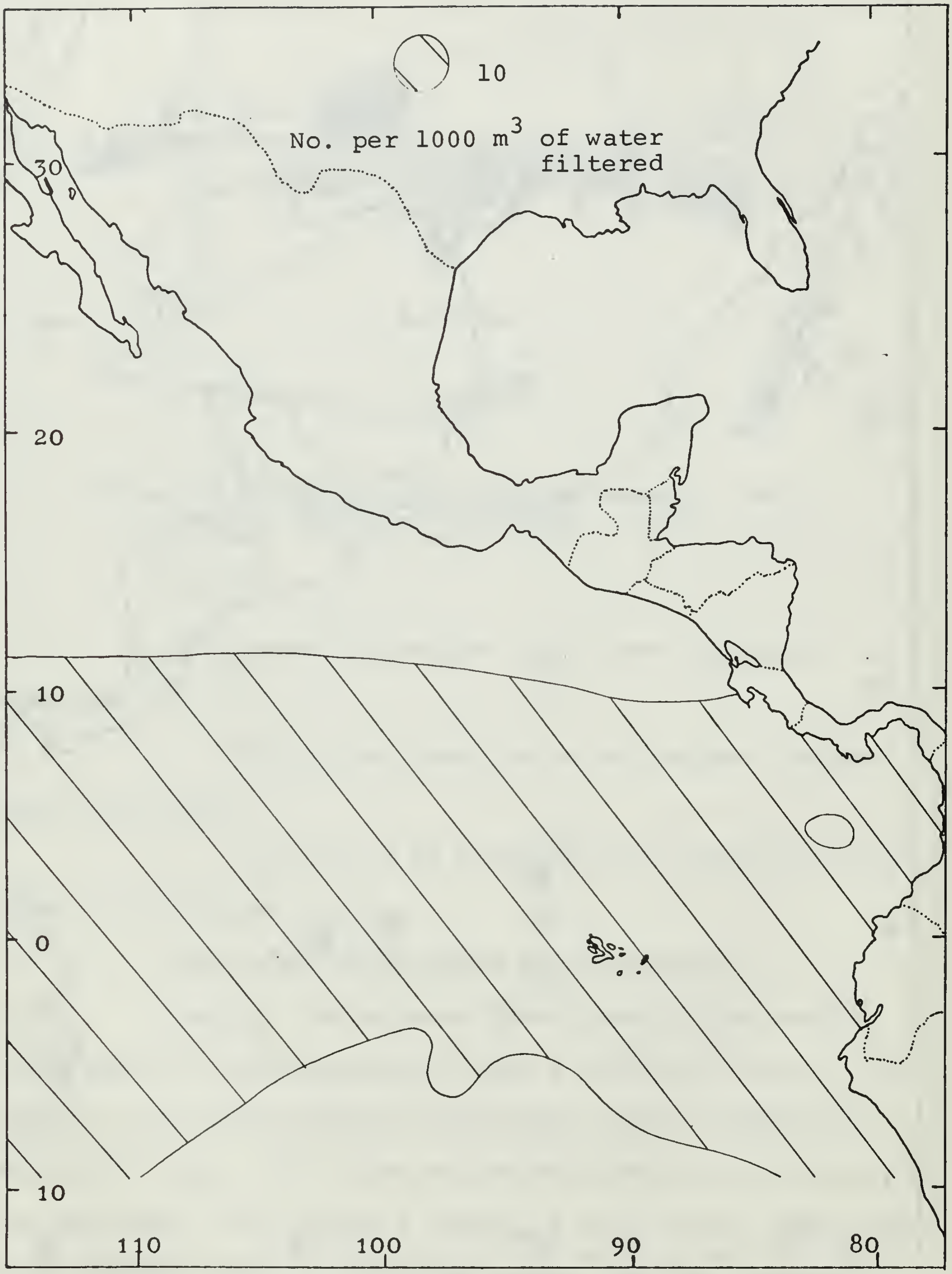



Figure 70. Horizontal Distribution of Stylocheiron maximum in the Eastern Tropical Pacific found by Brinton. (After Brinton, (1962))

| DEPTH (m) | DAY | NIGHT |
|---|---|---|
| 0-50 | NO DATA | 17-003○ 17-020○ 17-044○ 17-026○ 17-028○ 16-188○ 16-190○ |
| 50-100 | 17-016○ | 17-051○ |
| 100-150 | 17-050○ | 17-019○ 17-068○ |
| 150-200 | 17-058○ 17-060○ 17-061○ | 17-035○ 17-062○ |
| 200-250 | 17-010○ 17-015○ 17-040○ 17-041○ 16-191○ | 17-037⦶ |
| 250-300 | 17-008○ 17-070⊕ 16-193○ | 17-007○ |
| 300-350 | 17-047○ 17-048⦶ 17-066○ 17-069⦶ 17-072○ | 17-067○ |
| 350-400 | 17-032○ 17-042○ 17-043○ 17-057○ 16-184○ | 17-038○ |
| 400-450 | 17-017○ 17-071○ | NO DATA |
| 450-500 | 17-049○ | NO DATA |
| 500-550 | 17-059○ | 17-027○ |
| 550-600 | 17-018○ | 17-036○ |
| OTHERS | 1000-1050 17-031⊕ 16-192○<br>2000-2050 17-065○ | 650-700 16-186○<br>750-800 16-189○<br>1000-1050 17-029○ 17-064○<br>UNKNOWN DEPTH 17-055○ |

Figure 71. Diurnal Vertical Distribution of *Stylocheiron maximum* in the Eastern Tropical Pacific

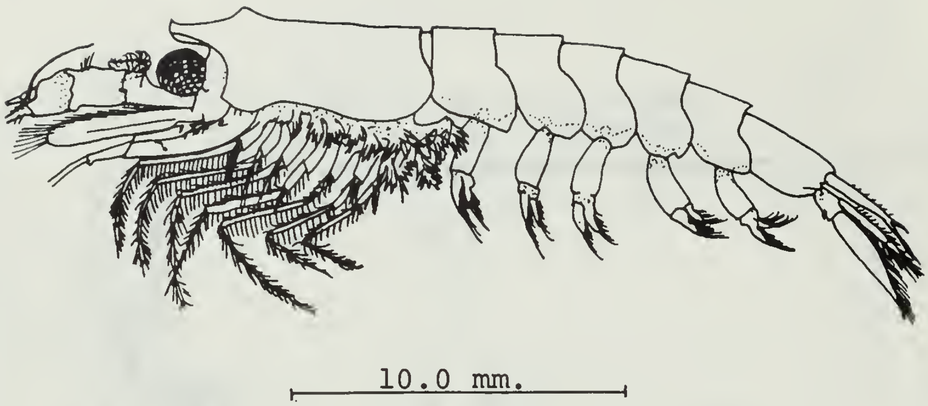


Figure 72. Thysanopoda orientalis Hansen. Adult female. (After Boden et al, (1955))

preceding ones. The exopodite of the eighth thoracic appendage is normal, but the endopodite is greatly reduced. The complex posterior gills are arborescent.

There are 14 known species in the genus. The one encountered is described here.

(1) Thysanopoda orientalis Hansen. The frontal plate is triangular, and the apical angle is greater than ninety degrees. A vestigial rostrum in the form of a short, forward- and upward-pointing tooth is present. The carapace lateral margin is smooth. The fourth and fifth abdominal segments posterior margins are slightly acuminate. The lobe on the basal segment of the first antennal peduncle is produced and pointed, but not spiniform. The second segment distal margin is produced and covers a part of the proximal surface of the third segment.

Length: 23-38 mm.

Adults are found below 400 meters; larvae occasionally above 200 meters.

A total of 26 specimens were found in three trawls (see Figures 73-75).

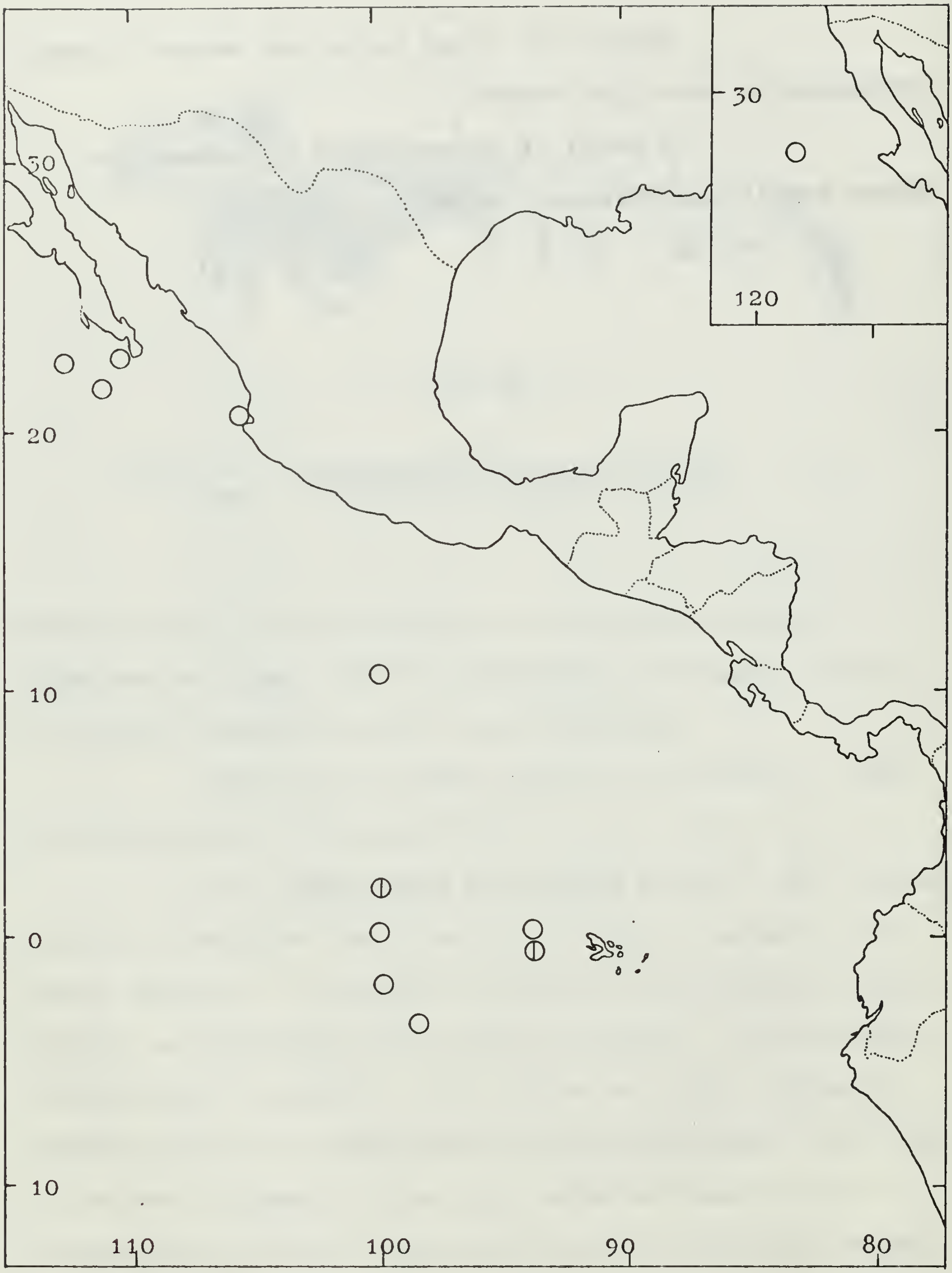



Figure 73. Horizontal Distribution of Thysanopoda orientalis in the Eastern Tropical Pacific

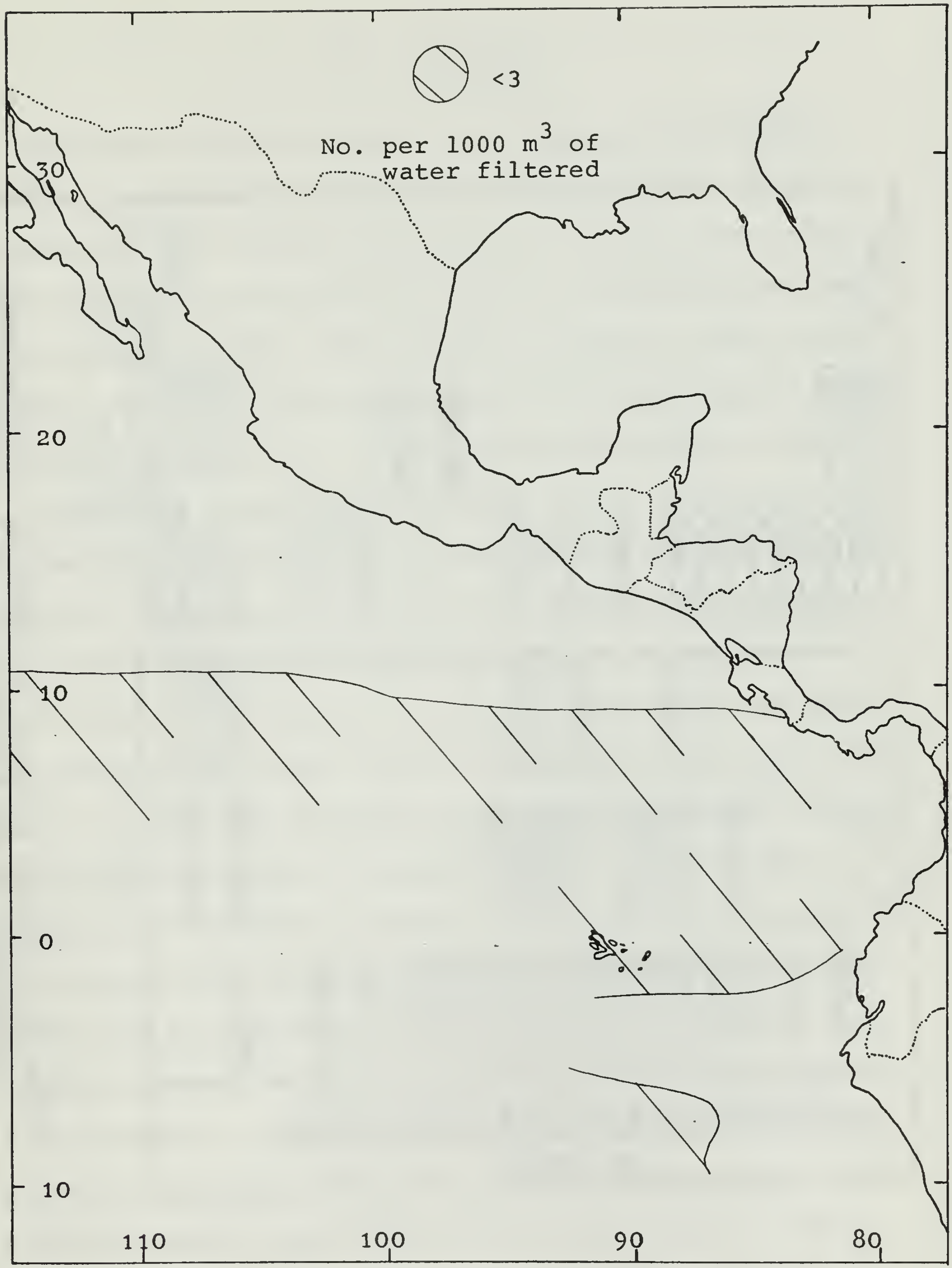



Figure 74. Horizontal Distribution of <u>Thysanopoda orientalis</u> in the Eastern Tropical Pacific found by Brinton. (After Brinton, (1962))

| DEPTH (m) | DAY | NIGHT |
|---|---|---|
| 0-50 | NO DATA | 17-003○ 17-020○ 17-044○ 17-026○ 17-028○ 16-188○ 16-190○ |
| 50-100 | 17-016○ | 17-051○ |
| 100-150 | 17-050○ | 17-019○ 17-068○ |
| 150-200 | 17-058○ 17-060○ 17-061○ | 17-035○ 17-062○ |
| 200-250 | 17-010○ 17-015○ 17-040○ 17-041○ 16-191○ | 17-037○ |
| 250-300 | 17-008○ 17-070○ 16-193○ | 17-007○ |
| 300-350 | 17-047○ 17-048○ 17-066○ 17-069○ 17-072○ | 17-067○ |
| 350-400 | 17-032⦶ 17-042○ 17-043○ 17-057⦶ 16-184○ | 17-038○ |
| 400-450 | 17-017○ 17-071○ | NO DATA |
| 450-500 | 17-049○ | NO DATA |
| 500-550 | 17-059⦶ | 17-027○ |
| 550-600 | 17-018○ | 17-036○ |
| OTHERS | 1000-1050 17-031○ 16-192○; 2000-2050 17-065○ | 650-700 16-186○; 750-800 16-189○; 1000-1050 17-029○ 17-064○; UNKNOWN DEPTH 17-055○ |

Figure 75. Diurnal Vertical Distribution of *Thysanopoda orientalis* in the Eastern Tropical Pacific

# IV. DISCUSSION

As can be seen from Figure 13, *Euphausia diomedeae* occurs throughout the area south of about 22°N. It was caught at night in the surface layer and during the day much deeper. There appears to be no relationship between this species and the water masses. A study of the entire Pacific (Brinton, 1962) showed that the distribution is closely associated with the Equatorial Subsurface Water.

*Euphausia distinguenda* (Figures 16-21) was found both throughout the Gulf of California and the Eastern Tropical Pacific. It's range was found to extend further north in the Gulf than Brinton (1962) had found. It was dominant more often in the horizontal region occupied by the Northern Central Gulf Water than in any other water mass in the Gulf. It occurred throughout the Eastern Tropical Pacific (Figure 19) except in the southwestern portion. The species was found to be present in all the water masses in the area above and including the Equatorial Subsurface Water, and is not associated with any one particular mass. Diurnal vertical migration is suggested by Figures 20 and 21. However, it should be noted that this study made no distinction between adult and juvenile euphausiids. Juveniles generally spend much or all of the time in the surface masses. This must be considered when trying to infer migrations from the vertical distribution figures in this paper.

Euphausia eximia (Figures 23-28) was the dominant species throughout the Gulf of California and the Eastern Tropical Pacific, except in the Gulf north of about 28°N, where it was sparse. Of the approximately 43,000 euphausiids examined, over 30,000 were Euphausia eximia. Figure 26 shows areas in the Eastern Tropical Pacific where the species is not present. These areas make up part but by no means all of the horizontal ranges of the Tropical Surface Water and the Subtropical Surface Water. The species was found throughout the southern part of the Gulf of California, a feature Brinton (1962) did not find. The species was found throughout the water column and is not associated with one particular water mass in the area. Diurnal vertical migration is suggested by Figures 27 and 28.

Euphausia gibboides (Figures 30-34) was found in most parts of the Eastern Tropical Pacific and was dominant most often along the equator. It was also found in the central and southern parts of the Gulf of California, whereas Brinton (1962) did not report Euphausia gibboides as present in the Gulf. Diurnal vertical migrations are suggested by Figures 33 and 34. There is no apparent association with a single water mass in the area.

Nematoscelis difficilis (Figures 36-38) was found only in the Gulf of California, where it was often the dominant euphausiid north of 25°N (Figure 36). As indicated by Figure 37, this species is also present in the California Current region. Diurnal vertical migration seems to be indicated from Figure 38. Brinton (1962) found no clear indication of this migration. It should be noted that this normally epipelagic species was present in a trawl from 2200 meters. Twenty-one of the 125 euphausiids from this deep trawl were *Nematoscelis difficilis*. No association with any single water mass in the area is apparent. Rather, it was found throughout the water column in all parts of the Gulf of California except the southeastern part, and in the California Current region.

*Nematoscelis gracilis* (Figures 40-44) was found both in the Gulf of California and the Eastern Tropical Pacific. The population in the Gulf was not abundant and was found in the areas occupied by the Northern Central Gulf Water and Southern Gulf Water. Brinton (1962) did not report occurrence in the Gulf. The species is also found throughout the Eastern Tropical Pacific. Although the data is sparse, it seems to suggest the diurnal vertical migration. The species was found to move up and down the water column from the surface layer to Equatorial Subsurface Water in the Gulf of California and to Intermediate Water in the Eastern Tropical Pacific. There is no apparent association with any one water mass in the area. Like *Euphausia diomedeae*, this species seems to be associated with the Equatorial Subsurface Water across the full extent of the Pacific (Brinton, 1962).

*Nematoscelis tenella* (Figures 46-48) was not found in the Gulf of California. It was found in the Eastern Tropical

Pacific south of about 12°N. Although the total number of specimens found was small there were trawls wherein it was dominant (Figure 46). Figure 48 suggests diurnal vertical migrations. This species also occurred throughout the water column down to Intermediate Water and does not appear to be associated with any certain water mass in the area.

Nematobrachion boöpis (Figures 50-52) was found in only one trawl in the Eastern Tropical Pacific near the equator. This mesopelagic species usually occurs deeper than the great majority of the trawls taken, normally between about 500 and 2000 meters in this area (Brinton, 1962), and has not been found to be abundant. Brinton's (1962) data indicates no relationship between distribution and water masses in the area other than the habitat being in the deep water masses.

Nematobrachion flexipes (Figures 54-58) was found in the central and southern portions of the Gulf of California, and in the Eastern Tropical Pacific from off southern Baja California southward. Brinton's (1962) data agrees, except he did not report Nematobrachion flexipes in the Gulf of California. No diurnal vertical migration in the Gulf is apparent from this data (Figure 57), however, this migration is suggested for the Eastern Tropical Pacific (Figure 58). This species was found throughout the water column (including the 2200 meter trawl in the Southern Gulf of California) and does not appear to be associated with any single water mass in the area.

*Nyctiphanes simplex* (Figures 60-63) was found only in the Gulf of California in the Northern Central Gulf Water and below. Brinton (1962) found it also in the California Current region and the Eastern TropicalPacific in the general area between the Galapagos Islands and Peru. Brinton (1962) reports large populations in the southern part of the Gulf of California, in areas where none were found during this expedition. Indeed, only 121 specimens were found at all. The specimens were found in the upper layers both during the day and night and most were above 100 meters during the day. *Nyctiphanes simplex* is associated with near-shore transition regions between warm and cold currents and coastal upwelling zones (Brinton, 1962).

*Stylocheiron abbreviatum* (Figures 65-67) was found in only six trawls in the Eastern Tropical Pacific, mainly along the equator west of the Galapagos Islands, but was also found off the tip of Baja California in one deep trawl. The location and the depth of this one occurrance is unusual. Data collected were too sparse to indicate vertical migration; Brinton (1962) found none. No relationship with water masses in the area was found.

*Stylocheiron maximum* (Figures 69-71) data were also sparse. The species was found in five trawls from the Eastern Tropical Pacific, along the equator, west of the Galapagos Islands. Brinton (1962) indicated there is no evidence of diurnal vertical migration. No apparent relationship with water masses in the area was found.

*Thysanopoda orientalis* (Figures 73-75) was found in only three trawls, all along the equator, west of the Galapagos Islands, in depths 350 to 550 meters, during the day. No apparent association with water masses in the area was found.

The above data seems to suggest that there is no relationship between the distribution of euphausiids and the distribution of water masses in the area considered. However, others have suggested that such a relationship does exist. Brinton (1962) noted that there was a distinct relationship between some euphausiids and some water masses in both horizontal and vertical extent. He described relationships between euphausiids and the major upper (150 to 1500 meters) water masses of the Pacific as given by Sverdrup *et al*, (1942).

That such relationships exist has been suggested for other zooplankton also. Bradshaw (1959) suggested it for pelagic foraminifera, Bieri (1959) for chaetognaths, McGowan (1960) for a planktonic worm, and Fager and McGowan (1963) for various zooplankton groups. These investigators did not consider the surface masses as was done in this study. Most of the adult euphausiids considered here do migrate up into these surface masses at night, but there appears to be no direct horizontal relationships.

That no relationships between water masses and euphausiids were found may be due to many factors. All of the species and all of the water masses considered (except those water masses defined by phytoplankton content in the Gulf of California) are more widely distributed than in the limited area investigated. When Brinton (1962) considered the entire Pacific Ocean he was able to show some distinct relationships. This suggests that the entire range of both the animals and the water masses must necessarily be considered. Many seasonal factors such as available food (plankton blooms), shifting currents, reproductive success, etc. may all be valid hypotheses for distributional changes. It is also well known that animals are quite variable and often ignore man-made classifications. Such indifference may have been a factor here.

It should also be emphasized that many more species other than those found are known to inhabit the area considered. Some inhabit it quite densely. The area coverage in the Gulf of California was quite good, yet several species reported to exist there were not found. Why only these 13 species were caught remains questionable. It may be due partly to patchiness and the relatively small number of trawls made.

## V. CONCLUSIONS

1. New information on the distribution of euphausiids in the Gulf of California has been presented here. Several species previously unreported in the Gulf were found to be present. These include *Euphausia gibboides*, *Nematoscelis gracilis*, and *Nematobrachion flexipes*.

2. No clear direct relationships between euphausiids and subsurface water masses were shown to exist in the limited area considered.

3. No clear direct relationships between euphausiids and surface water masses as defined by Round (1967) on the basis of phytoplankton content in the Gulf of California were shown to exist.

4. No clear direct relationships between euphausiids and surface water masses as defined by T-S relations were shown to exist.

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13. ABSTRACT

The object of this investigation was to determine the relationships between the euphausiid populations and the surface and subsurface water masses in the Gulf of California and the Eastern Tropical Pacific. The data was collected during two three month cruises of the R/V TE VEGA. Aspects of the horizontal and vertical distributions of both the euphausiids and the water masses are presented. Euphausiid distributons found by another investigator are presented for comparison. The study was based on 120 trawls which fished for a period of one hour each with an opening and closing Tucker midwater trawl. Thirteen different species of euphausiids were caught. The data suggests that there is no direct relationship between the distribution of euphausiids and the distribution of water masses in the limited area considered. New extensions of the horizontal and vertical ranges of several species of Pacific euphausiids are included.

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